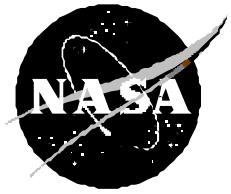
OCTOBER 31, 2008

AUDIT REPORT

OFFICE OF AUDITS

MORE STRINGENT ENTRANCE CRITERIA NEEDED FOR PROJECT LIFE-CYCLE REVIEWS

OFFICE OF INSPECTOR GENERAL



National Aeronautics and
Space Administration

REPORT NO. IG-09-004 (ASSIGNMENT NO. A-07-011-01)

Final report released by:

signed
Evelyn R. Klemstine
Assistant Inspector General for Auditing

Acronyms

CxP	Constellation Program
DAC	Design Analysis Cycle
GAO	Government Accountability Office
NPR	NASA Procedural Requirements
PDR	Preliminary Design Review
POD	Point-Of-Departure
PNAR	Preliminary Non-Advocate Review
RID	Review Item Discrepancy
SDR	System Definition Review
SRB	Standing Review Board
SRR	System Requirements Review

OVERVIEW

MORE STRINGENT ENTRANCE CRITERIA NEEDED FOR PROJECT LIFE-CYCLE REVIEWS

The Issue

In January 2004, the President announced a Vision for U.S. Space Exploration that directed NASA to retire the Space Shuttle by 2010 and develop new launch vehicles for missions beyond low Earth orbit. To achieve the Vision, one of NASA's first challenges is the acquisition and development of the Orion Crew Exploration Vehicle (Orion). In September 2006, NASA awarded a $3.9 billion contract to Lockheed Martin Corporation (Lockheed) for the design, development, testing, and evaluation of Orion with a period of performance through December 2011. In April 2007, the Agency and Lockheed negotiated a change to the contract effectively increasing the contract value to $4.3 billion and extending the performance period to October 2013.

Since the 1980s, NASA has had difficulty bringing a number of projects to completion including the building of a next-generation spacecraft. The Agency spent an estimated $4.8 billion and years of effort on never completed projects such as the National Aero-Space Plane, X-33, X-34, Space Launch Initiative, and the International Space Station Propulsion Module. To improve project outcomes, the Government Accountability Office (GAO) issued several reports recommending that NASA develop sound acquisition concepts to capture specific product knowledge at key junctures in product development prior to proceeding with the project. As a result, NASA revised its program and project management guidance to require program and project "life cycles" with life-cycle reviews at key decision points.

We initiated this audit because of the overall importance of the Orion Project and because it is one of the first space flight projects to implement the revised guidance. We evaluated NASA's management of the Orion acquisition during the initial life-cycle phase established by NASA Procedural Requirements (NPR) 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007, and the life-cycle reviews that occur during the initial life-cycle phase, "Concept and Technology Development" (Phase A).

Results

The Orion Project Office (Project Office) conducted a Phase A life-cycle review with a vehicle configuration (606 vehicle) that was not at the proper maturity level to proceed to Phase B. Specifically, a required engineering design analysis conducted prior to the

life-cycle review disclosed that the vehicle configuration required a reduction in weight, power, and instrumentation. However, instead of delaying the Phase A life-cycle review until the correct vehicle configuration (607 vehicle) could be reviewed, the Project Office proceeded with a nonconforming vehicle. As a result, a significant portion of the vehicle configuration that eventually did proceed to Phase B did not receive the benefit of a Phase A life-cycle review, nor was it completely evaluated for compliance with requirements.

NASA policy requires space flight projects to conduct life-cycle reviews during each phase of the project's life cycle. These reviews are considered essential elements of conducting, managing, evaluating, and approving space flight projects. The Project Office conducted each of the required Phase A life-cycle reviews for projects—the System Requirements Review (SRR) and the System Definition Review (SDR)—in accordance with NPR 7120.5D. The Orion Standing Review Board (SRB) conducted an independent life-cycle review—the Preliminary Non-Advocate Review (PNAR)—which provides the Agency an expert assessment of the progress against the project baseline.

As part of Orion's systems engineering process, the Project Office performs analysis cycle reviews during and after each life-cycle review. Included in Phase A is a design analysis cycle (DAC) that integrates the analysis required to support the SDR and demonstrates that the proposed system design and operational concept meet the mission goals and objectives. The pre-SDR DAC analysis disclosed that the 606 vehicle configuration required a redesign to reduce weight, power, and instrumentation to fulfill the mission. In addition, the analysis showed that because the vehicle did not meet the mass and weight requirements, the 606 vehicle would not be at the maturity level to proceed to Phase B, "Preliminary Design and Technology Completion."

NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," March 26, 2007, establishes the entrance criteria that each project needs to fulfill and the success criteria that the project must successfully demonstrate for each life-cycle review. NPR 7123.1A entrance criteria do not require known changes from engineering design analysis be incorporated into the relevant technical baseline products prior to holding the life-cycle review. Therefore, the Project Office could hold the SDR, on schedule, on the nonconforming vehicle instead of delaying the SDR until meeting the Constellation Program (CxP) mass and weight requirements. The Project Office entered the SDR process with the nonconforming vehicle configuration because it initiated a parallel "point-of-departure" (POD) activity, which it believed would ultimately satisfy NPR 7120.5D requirements with the least expenditure of Agency resources.

By conducting the SDR with the 606 vehicle configuration and declaring the SDR a success, the Project Office (and the SRB) communicated the impression that the 606 vehicle was at the maturity level needed to proceed to Phase B of the project's life cycle, when it was not. In addition, the Agency was obligated to pay Lockheed its award fee of $41.4 million, which was based, in part, on the SDR being held by August 31, 2007. The Project Office was able to conduct the review with the nonconforming vehicle

because NASA's life-cycle reviews' entrance criteria do not require that the project incorporate the results from engineering analysis cycles conducted prior to the life-cycle review.

Without a fully successful SDR, the acquisition methodology is materially undermined and the Agency cannot be assured that life-cycle milestones vital to success are achieved. NASA needs to ensure that the vehicle configuration and requirements are at the proper maturity level prior to starting and completing future life-cycle phases. By not doing so, there is increased risk that new development is conducted prematurely, with concomitant risk of costly rework and schedule slips in managing the multibillion dollar Orion Project.

Management Action

Our September 9, 2008, draft of this report recommended that NASA revise NPR 7123.1A entrance criteria for internal life-cycle reviews to require that the technical products reviewed incorporate into the technical baseline known requirement changes resulting from engineering analysis cycle assessments. In addition, to ensure that the 607 vehicle configuration was scrutinized at a minimum of the Phase A SDR level, we recommended that the Agency evaluate the vehicle configuration to determine the impact of any missed work and, if material, perform an SDR on affected systems. Finally, to ensure that the contractor does not prematurely receive award fees, we recommended the Agency ensure the contractor receive award fees based on the maturity of the relevant technical baseline rather than on holding a scheduled milestone.

Management's Comments and OIG Response. In response to a draft of this report (see Appendix G, "Management Comments"), the Chief Engineer did not concur with our recommendation to revise NPR 7123.1A entrance criteria, stating that the current policy is effective as written. The Chief Engineer also stated that there is no technical baseline of the design at this point in the life cycle. Trade studies and technology maturation are still occurring such that by the Preliminary Design Review (PDR), a preliminary design is in place that meets all system requirements.

We consider management's comment to this recommendation to be nonresponsive. We disagree that the current policy is effective. The policy as written provides for what amounts to a system status review rather than a life-cycle review to examine whether NASA had achieved a milestone in project development. While system status is useful, it is not what we believe is intended by the life-cycle review process, which focuses on technical maturity as opposed to calendar milestones. If the technical maturity established pursuant to criteria does not exist, a life-cycle review should not be declared a "success." Material deficiencies should be addressed and resubmitted for review.

The policy as written allowed the Orion Project Office to hold the SDR on a nonconforming vehicle configuration that did not meet known requirements nor was the

vehicle able to meet the review's success criteria. In addition, although there may not be a technical baseline for the actual design available for review at the SDR, NASA's guidance is clear that the Project is developing the technical baseline during this life-cycle phase. We commend the Project Office for delaying its PDR on two different occasions (and its consideration of a third delay), to ensure that the relevant technical baseline is reviewed. We believe these delays are consistent with making the PDR a true life-cycle review. However, without a revision to NPR 7123.1A requiring review of the relevant technical baseline at each life-cycle review, instances might again arise when reviews are performed on a premature configuration in compliance with the entrance criteria, yet be unable to meet known technical requirements or the success criteria. We request that the Chief Engineer reconsider his response to this recommendation and provide additional comments by November 26, 2008.

The Associate Administrator for Exploration Systems Mission Directorate did not concur with our recommendation to evaluate the Phase B vehicle configuration to assure that it was scrutinized at a minimum of the SDR level, stating that no additional review is warranted. However, the Associate Administrator did concur with our recommendation that the contractor receives award fees based on the maturity of the relevant technical baseline, stating that NASA had already acted accordingly for the first Orion award fee period covered during the audit.

Although the Associate Administrator for Exploration Systems Mission Directorate did not concur with our recommendation to evaluate the Phase B vehicle configuration, the Agency's actions are responsive to the intent of our recommendation. Technical subject matter experts and Agency stakeholders eventually evaluated the 607 vehicle configuration, albeit outside of the formal SDR process. We believe the Agency's delay of the Phase B PDR because the known technical baseline changes are not at the proper maturity level is consistent with our recommendation. Likewise, although we disagree with the Associate Administrator's assertion that NASA acted in accordance with the recommendation during award fee period one, Agency actions taken during award fee period two are in accordance with the recommendation. NASA adjusted the period two award fee milestone to coincide with the delayed PDR and by so doing, NASA demonstrated that the Orion Project acted in accordance with the intent of our recommendation. We consider these recommendations resolved and closed.

CONTENTS

INTRODUCTION

Background

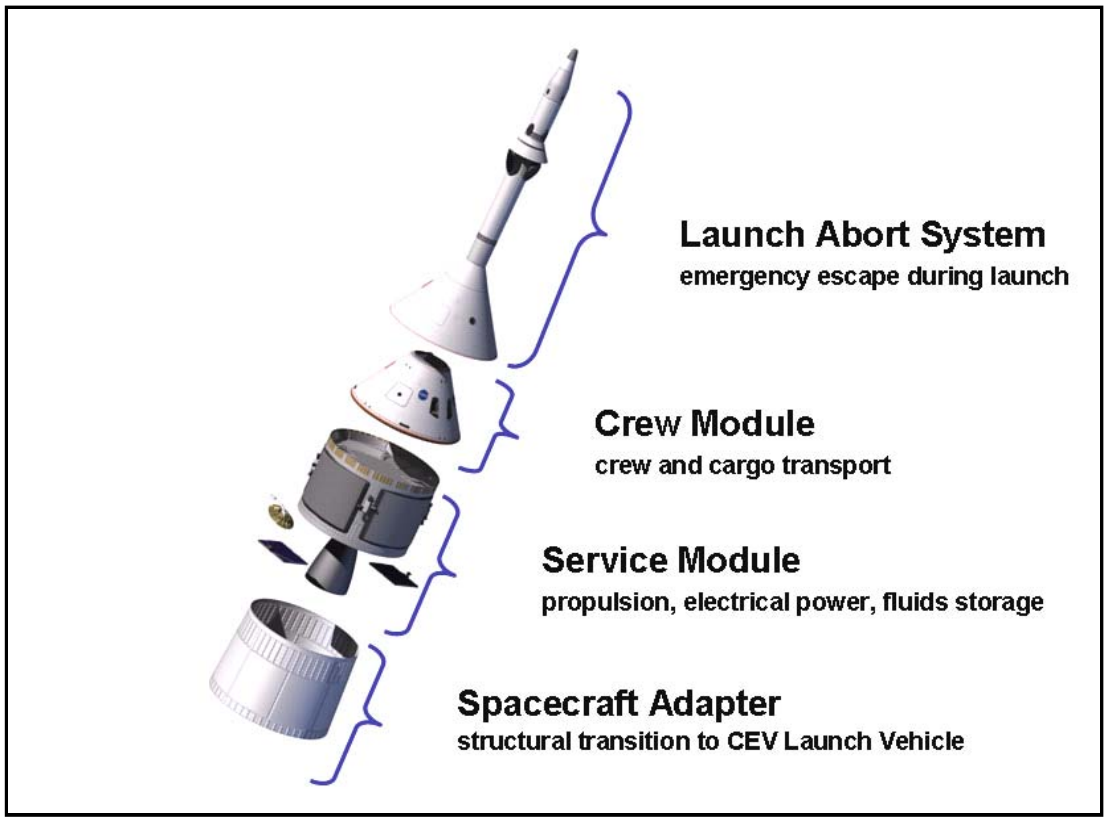
Orion is one of six projects under the Constellation Program (CxP).[1] CxP is managed from the Johnson Space Center (Johnson) and is responsible for designing and developing the next generation of NASA space vehicles, which will send human explorers back to the moon and onward to Mars and other destinations in the solar system. CxP scheduled the new space vehicles for three unmanned test flights in April 2009, September 2012, and March 2013, with the first manned flight about March 2015. NASA plans a manned flight to the moon before 2020.

Orion Crew Exploration Vehicle (CEV). Orion is the crew capsule for the next generation of space vehicles and will be used to transport crew and cargo from Earth to space and return. As shown in Figure 1, the Orion Project includes four elements: (1) a launch abort system (emergency escape during launch), (2) a crew module (crew and cargo transport), (3) a service module (propulsion, electrical power, and fluids storage), and (4) a spacecraft adapter (structural transition to CEV launch vehicle).

Orion will be capable of transporting up to six crewmembers to and from the International Space Station, four crewmembers for lunar missions, and pressurized cargo to and from the International Space Station without a crew. Orion will also support crew transfers for future Mars missions.

[1] The other five CxP projects are the Crew and Cargo Launch Vehicles (Ares I and Ares V), Ground Operations, Mission Operations, Extra-Vehicular Activity Systems, and Lunar Lander projects.

Figure 1. Orion Project Elements



Source: Crew Exploration Vehicle Project Plan, December 18, 2006

Orion Project Management. The development of Orion is a joint effort involving every NASA Center. While Johnson is leading the development of Orion's crew module, Langley Research Center is leading the development of the Orion launch abort system, and Glenn Research Center is leading development of the Orion service module and spacecraft adapter. Kennedy Space Center will lead the pre-flight processing and launch operations for Orion. Lockheed is NASA's prime contractor for the design, development, testing, and construction of Orion.

Project Management Guidance. NASA's primary project management guidance for space flight projects is contained in NPR 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007, and NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," March 26, 2007. NASA revised NPR 7120.5D and NPR 7123.1A in response to multiple GAO reports that recommended NASA change its approach to program and project management, specifically as it related to the acquisition process. GAO stated that NASA's acquisition framework did not provide the information needed to make major investment decisions, which contributed to NASA's difficulties in meeting cost, schedule, and performance objectives for its

programs and projects.[2] The revised NPR 7120.5D introduced the concept of program and project "life cycles" and defined the various key decision points and life-cycle reviews to manage each space flight program or project (see Appendix B for a space flight project's life cycle). The revised NPR 7123.1A established entrance and success criteria for each of the life-cycle reviews. The Orion Project was one of NASA's first space flight projects to implement that new guidance.

Objectives

The overall objective of this audit was to evaluate the management of the Orion acquisition. Because the acquisition was in the "Concept and Technology Development" phase of the project life cycle (Phase A), we reviewed and evaluated management's efforts to ready the project for the "Preliminary Design and Technology Completion" phase of the project life cycle (Phase B). We specifically focused on the life-cycle reviews conducted during Phase A—System Requirements Review (SRR), System Definition Review (SDR), and Preliminary Non-Advocate Review (PNAR). We also reviewed internal controls as they related to the overall objective. See Appendix A for details of the audit's scope and methodology, our review of internal controls, and a list of prior coverage.

[2] Government Accountability Office, "NASA-Implementing a Knowledge-Based Acquisition Framework Could Lead to Better Investment Decisions and Project Outcomes" (GAO-06-218, December 21, 2005).

ORION SDR CONDUCTED WITH A NONCONFORMING VEHICLE

Although the Orion Project conducted each of the Phase A life-cycle reviews required by NPR 7120.5D (SRR, SDR, and PNAR), the SDR was conducted with a vehicle configuration (606 vehicle) that did not meet mass and weight requirements levied by the CxP. An engineering design analysis conducted to refine the spacecraft for the SDR determined that the 606 vehicle configuration required a reduction in weight, power, and instrumentation before it could meet CxP requirements. Instead of delaying the SDR until a vehicle redesign was complete (607 vehicle), the Orion Project elected to hold the SDR with the nonconforming 606 vehicle and on August 30, 2007, reported in the SDR Board minutes that the SDR had been "successful." The Project Office was able to conduct the SDR with a nonconforming vehicle because NASA guidance does not require that results of engineering design analyses be considered when determining whether a project is ready for its next life-cycle review. By conducting the SDR and declaring it a success, the Project Office communicated the impression that the vehicle was at the maturity level needed to proceed to Phase B of the project's life cycle, when it was not. In addition, the Agency was obligated to pay the prime contractor its award fee of $41.4 million, which was based, in part, on the contractor holding the SDR by August 31, 2007.

Life-Cycle Review Process

NPR 7120.5D requires NASA space flight projects to conduct life-cycle reviews during each phase of the project's life cycle. The reviews are considered essential elements of conducting, managing, evaluating, and approving space flight projects. Generally, a project first conducts an "internal review," wherein the project management solidifies their plans, technical approaches, and programmatic commitments. During the internal review, functional area experts from across the Agency evaluate the project's technical documentation for noncompliance or conflicts with requirements. If a discrepancy is identified, the functional area expert will initiate and submit a review item discrepancy (RID).

RIDs can be initiated against incorrect, incomplete, or missing requirements or other areas in which the technical documentation is incomplete or in error. The RIDs go through a series of reviews whereby selected technical personnel further screen the RIDs and determine whether to recommend the RID for approval, approval with modification, dismissal, or merger with another RID. Approved RIDs are forwarded to a review panel and a pre-board; they ensure that the project's technical documents are revised in accordance with the RIDs and that the RIDs are properly dispositioned and closed.

Lastly, the internal project review board assesses the RID dispositions, schedules of forwarded RID work, and recommendations and closure plans for any outstanding RIDs. While all RIDs must be dispositioned prior to proceeding to the next life-cycle review, the RIDs do not have to be closed if the project has a plan to address the discrepancy. If a RID is dismissed during the review process, the initiator is notified and may issue a reclama directly to the internal project review board for consideration.

Once the internal review is complete, the project undergoes an independent review by the project's Standing Review Board (SRB). NPR 7120.5D requires that an SRB be established for each space flight project. The SRB reports on the adequacy and credibility of the project's technical and management approach, schedule, resources, cost, and risk; the project's compliance with Agency management and systems engineering guidance; and the project's readiness to proceed to the next life-cycle phase. SRB members are chosen based on their management, technical, and safety and mission assurance expertise; their objectivity; and their ability to make a broad assessment of space flight projects. To ensure the objectivity of the SRB, NPR 7120.5D requires that the members be independent of the project under review; that is, none of the members should have a stake in the outcome of any of the life-cycle reviews or in the project itself.[3] Because the SRB is solely an advisory board, NASA management is not required to act on the SRB's findings and recommendations; however, NASA management must consider the SRB report when deciding whether the project should proceed to the next life-cycle phase.

Phase A Life-Cycle Reviews

During Phase A of a space flight project's life cycle, the project undergoes three life-cycle reviews—SRR, SDR, and PNAR. The results from those reviews are presented to the decision authority who determines the readiness of the project to progress to Phase B[4] of the life cycle.

SRR. The SRR is the project's first Phase A life-cycle review in which the functional and performance requirements and the preliminary project plan are examined to ensure that the requirements and selected concept will satisfy the mission. Prior to initiating the SRR, a project needs to fulfill the entrance criteria listed in NPR 7123.1A, Appendix G, Table G-4, "SRR Entrance and Success Criteria" (see Appendix C). Those entrance

[3] In a previously issued NASA OIG report (IG-08-018, "Final Memorandum on the Standing Review Board for the Orion Crew Exploration Vehicle Project," April 28, 2008), we found that not all Orion SRB members met the independence requirements as defined in NPR 7120.5D. Based on our finding, the Agency is revising its SRB guidance.

[4] Phase B is the second phase of a project's life cycle and culminates with the preliminary design review, which is the first life-cycle review in the Phase B life-cycle and provides information for Key Decision Point C.

criteria require that the project successfully complete a Mission Concept Review,[5] prepare a preliminary SRR agenda, and define success criteria by which the project will be measured. The project must also have a number of technical products available for the functional area experts and the SRB to review including the system requirements documents, the baselined systems engineering management plan, the risk management plan, and the system safety and mission assurance plan. At the conclusion of the SRR, the project must demonstrate to the SRR internal review board that it has met the SRR success criteria listed in NPR 7123.1A, to include development of a sound process for allocating and controlling requirements and a method of validating those requirements. The project must also have identified and technically assessed its major risks and developed mitigation strategies to address those risks.

SDR. The SDR is the project's second Phase A life-cycle review in which the proposed requirements, the mission/system architecture, and the flow down of requirements to all functional elements are reviewed. As with the SRR, the project needs to fulfill the SDR entrance criteria before proceeding with the review (see Appendix D). Those entrance criteria require that the project have successfully completed its SRR, prepared a preliminary SDR agenda, and have certain technical products, such as the preliminary functional baseline (with supporting trade-off analyses and data), available for the functional area experts and SRB review. In addition, any updates to the technical products initially reviewed during the SRR are resubmitted for the SDR. At the conclusion of the SDR, the project must demonstrate to the SDR internal review board that it has met the SDR success criteria. Included in NPR 7123.1A's list of success criteria is an allocation of all technical requirements, development of a credible technical approach that is responsive to the identified requirements, and the existence of a process to manage the identified and technically assessed development, mission, and safety risks. The project must also demonstrate that the requirements, design approaches, and conceptual design can fulfill the mission needs consistent with available resources (cost, schedule, mass, and power).

PNAR. The PNAR is the Phase A independent life-cycle review and is conducted to specifically provide NASA management with an independent assessment of the project's readiness to proceed to Phase B of its life cycle. The PNAR is conducted solely by the SRB and is designed to be held in conjunction with the project's SDR. The PNAR is considered complete when the SRB out-briefs the decision authority.

SRR Entrance and Success Criteria Met

The Orion 606 vehicle configuration met the SRR entrance and success criteria established in NPR 7123.1A. As required by the NPR's entrance criteria, the project documented its SRR agenda, defined success criteria to measure the Orion's progress,

[5] The Mission Concept Review is conducted during Pre-Phase A to affirm the mission needs, examine the proposed objectives, and examine the concept for meeting those objectives.

and provided the required technical products to the functional area experts and the SRB for review. Although the project did not conduct a separate Mission Concept Review as required by the SRR entrance criteria, the project was able to justify that the Mission Concept Review objectives were accomplished as part of the Exploration Systems Architecture Study,[6] which preceded the Orion Project start.

The Orion SRR was initiated in January 2007 and from January 23, 2007, through February 26, 2007, the functional area experts evaluated the SRR technical documentation for assurance that requirements were necessary, achievable, verifiable, clear, and consistent. Deficiencies resulted in RIDs, which were processed through the formal RID disposition process. Ultimately, the Orion Project's internal SRR Board reviewed a summary of the RID dispositions along with its review of project requirements, technical status, design compliance, closure criteria, schedules of forwarded work, and recommendations and closure plans for open items. Based on that review, the SRR Board concluded on March 1, 2007, that the Orion Project had met all the requirements needed for a successful SRR to include meeting the SRR success criteria. In addition, the SRB also completed its independent review, concluded that the SRR was complete, and recommended the Project proceed to SDR with the 606 vehicle configuration.

Based on our analysis of the SRR entrance and success criteria and evaluation of the Orion Project's support for meeting those criteria, we agreed with management's determination that the Project successfully completed its SRR and that the 606 vehicle configuration was at the maturity level needed to proceed to the SDR. Our evaluation included reviewing documentation to support that the Exploration Systems Architecture Study accomplished the intent of the Orion Mission Concept Review, verifying that key driving requirements were identified, as prepared, and verifying that traceability functions were performed on those requirements. The Project Office provided us with documentation illustrating how CxP requirements trace to the subsystem level and we observed an example of the requirements flow down. We verified that the system and subsystem conceptual design approach and operational concepts existed and were consistent with the Orion's system requirement set. In addition, we verified that the Project had a Risk Management Plan, identified major risks, and defined mitigation strategies. We evaluated the Orion Project's RID process and the Project was able to show evidentiary matter that all RIDs and action items were dispositioned. We attended the SRR Board meeting on March 1, 2007, and reviewed the Board minutes for decisions made and forward action plans. We also reviewed the SRB's issued report to verify that the SRB concluded that Orion should proceed to the SDR.

[6] The Exploration Systems Architecture Study was chartered by the NASA Administrator to complete an assessment of the top-level Crew Exploration Vehicle requirements.

SDR Success Criteria Not Met

Although the Orion 606 vehicle configuration met the SDR entrance criteria, it did not meet the SDR success criteria because the 606 vehicle configuration used during the SDR did not meet known mass and weight requirements levied by the CxP.

At the completion of the SRR, NASA management and the SRB agreed that the 606 vehicle configuration was adequate to proceed to SDR. In preparation for the SDR, the Project Office initiated a "pre-SDR DAC" on the 606 vehicle configuration. The DAC is required by Orion's System Engineering Management Plan[7] and supports the SDR by demonstrating that the proposed system design and operational concept meets the mission goals and objectives. During the DAC, multiple project office organizations analyzed the system requirements, risks, system concept and architecture, trades assessments, and cost and schedule. (See Appendix E for the summary of all Orion's planned analysis cycles during its life cycle.) The Project Office completed the DAC in June 2007 and concluded that the SRR 606 vehicle configuration required a reconfiguration to reduce weight, power, and instrumentation to meet CxP requirements and proceed to Phase B. Known CxP requirements included a vehicle with a target payload mass of 50,250 pounds (5,522 pounds less than the 606 vehicle's effective payload mass of 55,772 pounds) and gross lift-off target weight of 66,504 pounds (4,387 pounds less than the 606 vehicle's gross liftoff weight of 70,891 pounds).

To address the mass and weight deficiencies disclosed during the DAC, the Project Office initiated a reconfiguration activity denoted as the POD activity. On June 8, 2007,[8] the Orion Project Manager and the Lockheed Orion Program Manager signed memorandum ZV-07-005 outlining that a Phase B vehicle reconfiguration activity would be performed simultaneously with the SDR. The memorandum stated that the vehicle configuration resulting from the POD activity would be the 607 vehicle that would proceed to Phase B. (See Appendix F for a copy of the complete memorandum.) To accomplish the POD activity, the Project Office examined the existing 606 vehicle and "stripped back" (took out) all components and functions requirements that were not vital to the lunar mission. The stripped back vehicle was denoted as the "Zero Based Vehicle" and the components and functions removed were maintained in a database that was the principal repository for identifying any removed items. Each item maintained in the database was prioritized to meet safety, robustness, and mission objectives and the weight, power, and thermal margins. After the prioritization, components and functions were then added back to the Zero Based Vehicle as allowed by the mass and weight margins. The Project Office had two rounds of "buy backs" where components and functions were added back to the vehicle. The first round of buy backs focused on safety, while the second round of buy backs focused on the remaining components and functions

[7] CxP 72088, "Crew Exploration Vehicle Systems Engineering Management Plan," November 8, 2006.

[8] The Project Office erroneously dated the memo June 8, 2006. We confirmed with the Project Office that the date should be June 8, 2007.

in the database. The Orion Vehicle Integration Office and Lockheed Systems Engineering and Integration Team led the effort with the Orion Vehicle Engineering Integrated Working Group performing the day-to-day activities. The Orion Vehicle Engineering Integrated Working Group performed the POD activity to establish requirements for the 607 vehicle in parallel with the Project Office's SDR of the 606 vehicle.

Consistent with the decision to hold the POD and SDR simultaneously, the Project Office initiated the SDR on July 11, 2007, with the 606 vehicle configuration, which did not meet known CxP mass and weight requirements and, therefore, could not meet the SDR success criteria. Specifically, the 606 vehicle did not meet the SDR success criteria that states "[t]he requirements, design approaches, and conceptual design will fulfill the mission needs consistent with the available resources (cost, schedule, mass, and power)." In addition, because the 606 vehicle's payload mass and lift-off weight could not meet the mission needs, we do not believe that Orion met the success criteria that "[t]he technical approach is credible and responsive to the identified requirements." Furthermore, until the POD activity was complete, the success criteria "[t]he tradeoffs are completed, and those planned for Phase B adequately address the option space" could not be met.

The Project Office conducted the SDR in accordance with NPR 7120.5D and met the NPR 7123.1A entrance criteria as written. The Project Office met NPR 7123.1A's entrance criteria by demonstrating the successful completion of the SRR, providing a preliminary SDR agenda, providing the SDR success criteria, and providing the technical documents for review to the functional area experts and the SRB. According to the Assistant Orion Project Manager for Integration, the Project Office believed that its strategy of performing the SDR parallel with the POD activity would ultimately address NPR 7120.5D requirements with the least expenditure of Agency resources.

At the conclusion of the SDR, the SDR Board documented in the Board minutes that the 606 vehicle design did not meet the mass requirements and trade studies could not be completed because the POD activity was ongoing. In addition, the Board minutes identified that although the SDR process allowed for a thorough review of the 606 vehicle, the POD activity (607 vehicle) would have relatively little review time and there was a concern about the tight schedule. On August 30, 2007, the SDR Board declared the SDR successful by asserting that the SDR was a snapshot review to understand the issues and the Project had plans, such as the POD activity, to address those issues.

To evaluate whether the Project Office conducted the SDR in accordance with NPR 7123.1A, we verified how the entrance criteria were met. As discussed earlier, the Project Office successfully completed the SRR and dispositioned all the SRR RIDs and action items resulting from the SRR. The SDR Process Plan[9] documented the purpose of

[9] CxP 72107, "Constellation Program Crew Exploration Vehicle System Definition Review Process Plan," June 22, 2007.

the SDR as well as the entrance and success criteria the Project would meet. We attended the SDR Kick-off meeting and observed several pre-board meetings. In addition, the required technical products were made available for the functional area experts and the SRB to review. We concluded that the Project Office's documented entrance criteria were met. However, the entrance criteria as written failed to incorporate known technical baseline changes prior to the life-cycle review. The POD activity was based on known mass and weight issues that could result in integrated design impacts across all subsystems addressing Orion's mass and power and result in reassessments of reliability, operability, safety, and cost.

Based on our review of the parallel POD activity, attendance at the board meetings, and the SDR Board minutes, we believe that the 606 vehicle did not meet the success criteria because the design did not fulfill the known mission needs consistent with the available resources. The vehicle did not meet the mass and weight criteria, thus the technical approach was not responsive to identified CxP requirements and the tradeoffs (POD activity) were not complete. As a result, the SRB was not able to conduct its PNAR in conjunction with the SDR.

PNAR Not Conducted in Conjunction with SDR

The SRB declined to conduct the PNAR in conjunction with the SDR because the 606 vehicle reviewed at the SDR did not meet requirements. The SRB requested that the Project Office provide them a briefing after the POD activity established the correct vehicle configuration (607 vehicle), which was scheduled for November 2007. During a September 27, 2007, interview with our office, the SRB Chairman stated that the vehicle configuration that went through the SDR (606 vehicle) was irrelevant. The SRB was subsequently briefed on the 607 vehicle configuration in December 2007 and was able to review the Phase B vehicle. Based on the December 2007 briefing, the SRB issued its PNAR report[10] on January 23, 2008, which stated that the Project faced significant technical issues[11] that would require major efforts to resolve before a valid Preliminary Design Review (PDR) could be conducted. The SRB report also noted that the schedule was not achievable within the defined budget and that the assessed cost was significantly higher than the currently defined budget. However, despite the issues and concerns documented in the PNAR report, the SRB recommended to the decision authority that the Project should proceed, with the 607 vehicle configuration, to its PDR in Phase B. The SRB out-briefed the decision authority on April 29, 2008, with the results as written in the PNAR report.

[10] Orion Project Standing Review Board "Assessment Report System Definition Review (SDR) & Preliminary Program Approval Review (PPAR)," January 23, 2008

[11] The technical issues include mass-margin threats, design impact threats from Ares I thrust oscillations, and an adequate definition for loss of crew and loss of mission.

Entrance Criteria Do Not Require Incorporation of Design Analysis Results

NASA's entrance criteria do not require that projects incorporate results of engineering design analyses (the DAC in this case) before initiating the life-cycle review, which allowed the Project Office to conduct the SDR with the nonconforming 606 vehicle. The entrance criteria do require that projects respond to all prior life-cycle review's request for actions and RIDs (the SRR in this case). However, the entrance criteria do not require that known changes to the technical baseline resulting from the required engineering analysis cycles performed between life-cycle reviews be incorporated into project technical documents. If the entrance criteria had considered the design analysis results, the SDR would not have concluded on August 30, 2007, but would have been delayed until the POD activity assessment was complete. NPR 7123.1A states that an important point of a life-cycle review is that ". . . reviews are event based and occur when the entrance criteria for the applicable review as specified in Appendix G are satisfied. They occur based on maturity of the relevant technical baseline as opposed to calendar milestones . . .." Although NPR 7123.1A provides entrance criteria for a life-cycle review to begin, the criteria do not address the maturity of the relevant technical baseline. The entrance criteria state that the previous life-cycle review (SRR in this case) must be complete; however, the criteria do not require that known changes in the technical baseline be incorporated prior to starting the review. The Project Office was able to hold the SDR on the nonconforming 606 vehicle, on schedule, because NPR 7123.1A entrance criteria do not incorporate the results of engineering design analyses even though the project is required to conduct the design analysis prior to the life-cycle review. The Project Office proceeded with the SDR instead of adjusting the SDR milestone even though it became apparent in June 2007 that the appropriate technical baseline (607 vehicle) would not be ready for the scheduled SDR.

"Successful" SDR Implied Phase B Maturity Level

The Orion Project Office did not fully meet the criteria to declare the SDR successful because the 606 vehicle configuration did not fulfill the mission needs. The 606 vehicle required a reconfiguration to reduce weight, power, and instrumentation in order to meet requirements before proceeding to Phase B. By conducting the SDR and declaring it a success, the Project Office communicated the impression that the SDR vehicle was at the maturity level needed to proceed to Phase B of its life cycle, when it was not. As stated in NPR 7120.5D, "NASA places significant emphasis on project formulation because adequate preparation of project concepts and plans is vital to success." During formulation (Phase A and Phase B), project staff develops and defines the requirements, cost, and schedule and designs a plan for the project to proceed to the implementation phases.[12] NPR 7120.5D also states that project reviews "are essential elements of

[12] Implementation phases are Phase C, Final Design and Fabrication; Phase D, System Assembly, Integration and Test, and Launch; Phase E, Operations and Sustainment; and Phase F, Closeout.

conducting, managing, evaluating, and approving space flight programs/projects." Additionally, as part of the required NPR 7123.1A engineering process, Orion's documented engineering process states that any changes to the requirements that occurred since the SRR will be verified at the SDR.[13] The purpose of the SDR is essentially negated if a known incorrect or irrelevant design is reviewed. Without a proper SDR, the Agency has limited assurance that project concepts and plans vital to success are achievable.

Since the 607 vehicle configuration that proceeded to Phase B was not reviewed by all functional area experts during the SDR, the redesigned vehicle did not go through the rigorous RID process to determine whether the technical data was in conflict with requirements. As such, the functional area experts did not validate a significant portion of the redesigned vehicle. A vehicle design that does not benefit from the rigors of the full SDR review process could lead to extensive rework, schedule slippage, and increased cost because an unacceptable design was allowed to proceed. For example, on the International Space Station's Propulsion Module Project, NASA did not validate requirements from the SRR before beginning the PDR. As a result, the Agency spent $97 million and 19 months of effort before it determined that the design was unacceptable.[14] The Orion SDR process evaluated the 606 vehicle and implied it was at the maturity level to proceed to Phase B; however, the vehicle configuration that will proceed to Phase B is the POD 607 vehicle. Although the 607 vehicle configuration received constant review and analysis from the Project Office and CxP, and the SRB was ultimately able to perform the independent PNAR (albeit about 4 months later), the 607 vehicle configuration did not obtain the full SDR environment review process as required by NPR 7120.5D. The Project Office should have delayed the SDR until the 607 vehicle configuration was ready because they knew the 606 vehicle configuration was not the vehicle going to Phase B.

Award Fee Paid Prior to SDR Milestone Completion

NASA awarded the prime contractor its award fee of $41.4 million[15] because, in part, the contractor held the SDR by August 31, 2007, and the Project Office considered the SDR successful. NASA's contract with Lockheed is performance milestone driven, which means that interim award fee periods and provisional payments are based on the contractor's successful completion of milestones within the agreed-to schedule. Lockheed's award fee plan states that

[13] Orion's engineering process is documented in CxP 72088, "Crew Exploration Vehicle, Systems Engineering Management Plan," November 8, 2006, and Revision A, July 10, 2007.

[14] NASA OIG, "Acquisition of the Space Station Propulsion Module" (IG-01-027, May 21, 2001).

[15] The total potential award fee was $[redacted] million. However, NASA only pays up to 80 percent of the maximum potential award until the end of the contract when any adjustments may be calculated and applied.

> Each award fee period will be based on objective project milestones identified in this plan and contract schedule. Each Interim award fee period and provisional payment is based on the Contractor's successful completion of the milestone(s) agreed to and as identified in the Contractor's Integrated Master Schedule. The award fee distribution table contained in Enclosure II, Performance Milestones, provides a list of performance milestones and available provisional fee for each milestone.

Enclosure II of the award fee plan specified that the SDR would be held by August 31, 2007. If the Project Office had delayed the SDR until the 607 vehicle configuration activity was completed, NASA would have been required to modify Lockheed's award fee plan to compensate for the SDR slippage past August 31, 2007. However, the Project's SDR Board met on August 30, 2007, and declared the SDR "successful" despite performing the review on a vehicle configuration that did not meet CxP requirements. In its self-evaluation for the award fee milestone, Lockheed stated that the SDR was successful. The contracting officer's technical representative's[16] September 27, 2007, presentation to the award fee evaluation board confirmed that an activity for this award fee period was to conduct the SDR Board on August 30, 2007. Based on these and other presentations, on September 27, 2007, the award fee evaluation board graded Lockheed's performance as excellent,[17] which resulted in Lockheed receiving the maximum award fee available.

Conclusion

History has demonstrated that NASA has had difficulty bringing a number of projects to completion including building a next-generation spacecraft. Since the 1980s, NASA has unsuccessfully attempted several development efforts estimated to have cost approximately $4.8 billion (National Aero-Space Plane, X-33, X-34, and Space Launch Initiative). In July 2006, GAO reported concern about NASA's acquisition strategy for Orion.[18] GAO stated that NASA's strategy of awarding a long-term contract for design, development, production, and sustainment before developing a sound business case[19] placed the Orion Project at risk of significant cost overruns, schedule delays, and performance shortfalls.

In October 2007, GAO reported that NASA had been taking steps to build a business case for the Ares I Crew Launch Vehicle Project,[20] to demonstrate that the project was

[16] The contracting officer's technical representative supports the contracting officer through surveillance of the contractor's performance and provides overall technical management of the contract.

[17] Award fee evaluation scoring follows standard adjectival ratings. The score of "excellent" is defined as "of exceptional merit; exemplary performance in a timely, efficient, and economical manner; very minor (if any) deficiencies with no adverse effect on overall performance."

[18] GAO, "NASA: Long-Term Commitment to and Investment in Space Exploration Program Requires More Knowledge" (GAO-06-817R, July 17, 2006).

[19] GAO defines a sound business case as one in which requirements match available and reasonably expected resources before committing to a new product development effort.

[20] The Ares I Crew Launch Vehicle is being designed to launch the Orion into space.

achievable within the constraints of time, money, and other resources but noted gaps in knowledge about requirements, costs, schedule, technology, design, and production feasibility. GAO stated that while NASA still had 10 months under its own schedule to close gaps in the development of the Ares I system, the gaps GAO identified were significant and challenging given the complexity and interdependencies in the CxP. For example, continued instability in the design of Orion hampers the Ares I Project's efforts to establish firm requirements.[21]

In April 2008, GAO testified that while NASA was working toward PDR for Ares I and Orion, there are considerable unknowns as to whether NASA's plans could be executed within schedule and cost goals. This was because NASA was still in the process of defining many performance requirements that could affect the mass, loads, and weight requirements. GAO stated that NASA was aiming to complete this process in 2008, but the Agency would be challenged to do so with the level of knowledge that still needed to be attained. GAO also indicated that NASA recognized the risks involved with its approach and had taken steps to mitigate some of these risks.[22]

In response to the multiple GAO reports, NASA revised its acquisition policy in 2005 and again in 2007. The policy revisions were a positive step in improving NASA's ability to complete its programs and projects within cost, schedule, and performance parameters. However, implementation of those revisions created its own challenges because it fundamentally changed NASA's approach to acquisition. For example, personnel within the Exploration Systems Mission Directorate had to balance the need to timely develop new space vehicles with the discipline necessary to follow and comply with the revised guidance.

The purpose of the life-cycle approach to project acquisition is to develop the maturity of a project to a satisfactory degree before proceeding to the next life-cycle phase of development. This process is important to assure the project is ready for additional investment and to signal readiness for new and more advanced development. Reviews are incorporated in each life cycle to assure readiness to proceed to the next phase.

This acquisition methodology is materially undermined when the review process is engaged when material challenges and questions with the current stage, or its design, are substantially unresolved. First, without resolution of questions that are fundamental to the life cycle's phase of maturity, conducting a review is inherently untimely and wasteful of effort. Second, it denies the project of the life-cycle review necessary and appropriate when the project achieves the maturity level at which it should be reviewed.

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

[22] GAO, Ares I and Orion Project Risks and Key Indicators to Measure Progress" (GAO-08-186T, April 3, 2008).

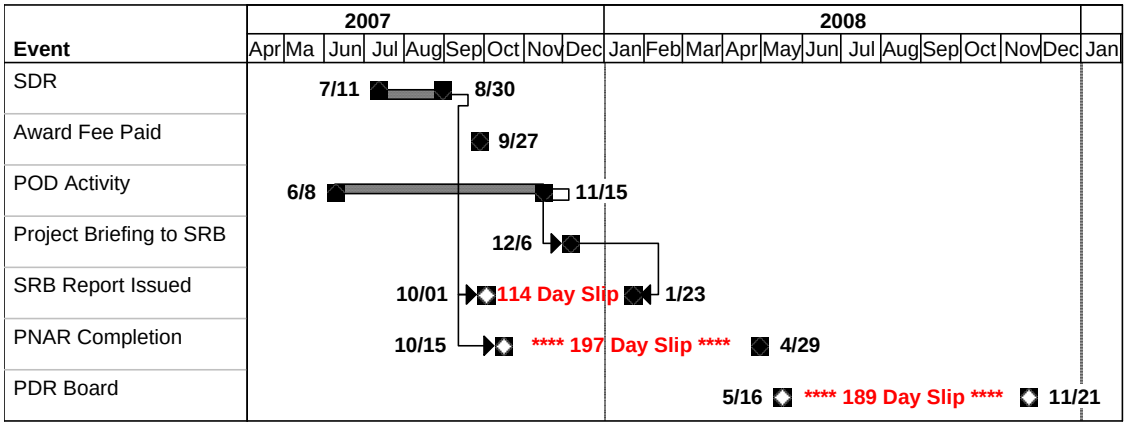
NASA has a unique opportunity to improve its processes concurrently with the acquisition of new space vehicles. However, successful implementation of those processes will depend on management's commitment to change and its ability to encourage compliance by all personnel in the acquisition process.

The Orion Project Office believed its strategy of the parallel POD activity ultimately addressed the NPR 7120.5D life-cycle review requirements with the least expenditure of Agency resources. However, by not delaying the SDR in order to review the proper vehicle configuration, a significant portion of Orion requirements did not go through the SDR RID process. Although the SDR process and life-cycle reviews are designed to find and correct discrepancies, the process cannot be expected to work as designed if a significant portion of the requirements do not go through that process. In addition, the project risks the untimely identification of discrepancies in Phase B that should have been identified earlier in the Phase A reviews. NASA needs to ensure that the vehicle configuration and requirements are at the proper maturity level prior to starting and completing future life-cycle milestones. By not doing so, there is increased risk of costly rework and schedule slippage.

Management Action

The Orion Project Office's effort in recognizing and correcting significant deficiencies in the vehicle configuration deserves special consideration. After the SDR, the Project Office correctly delayed the planned Phase B timeline because the SDR vehicle configuration was not ready and the Project had not made sufficient progress on meeting design changes adopted from the POD activity (see Figure 2).

Figure 2. SDR and Changes to Planned Phase B Timeline



With the extension, the SRB provided a report on January 23, 2008, instead of October 2007, the conclusion of the PNAR slipped from October 2007 to April 2008, and Orion's PDR Board, originally scheduled for May 2008, has slipped twice from September 2008 to November 2008. The Project Office is considering an additional

delay for the PDR to 2009. In anticipation of the PDR slip to 2009, NASA extended the second performance milestone of the award fee plan, which requires that Phase B's PDR Board be held by May 31, 2009. NASA needs to continue to adjust milestones and the contract as needed and avoid performing future life-cycle reviews prematurely.

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

Recommendation 1. The Chief Engineer should revise NPR 7123.1A's internal life-cycle reviews' entrance criteria to require the project to update the life-cycle review's technical products with known changes to the technical baseline resulting from engineering analysis cycle assessments.

Management's Response. The Chief Engineer nonconcurred, stating that while the intent of the recommendation is understood, the actual events show that the current policy is effective. He stated that the members of the Agency Program Management Council reviewed the results of the Orion SDR and the PNAR and determined that the SDR/PNAR milestone was successfully completed. In addition, Management approved the strategy of executing the SDR activities in parallel with the "Point of Departure" review to fully inform the Agency decision process and ensure a sound basis for beginning Phase B. The Chief Engineer also stated that there is no technical baseline of the design at this point in the life cycle. Trade studies, technology maturation, etc. are still occurring such that by the PDR, a preliminary design is in place that meets all system requirements.

Evaluation of Management's Response. Management's comments are nonresponsive. We disagree that the actual events show that the current policy is effective. We believe that the policy allowed the Orion Project Office to prematurely hold the SDR on a vehicle configuration that did not meet known requirements and therefore, would not meet the review's success criteria.

Although we agree that there may not be a technical baseline for the actual design available at the SDR, NASA's guidance explains that the Project is developing the technical baseline during the life cycle phase. As stated in our report and in NPR 7123.1A, life-cycle reviews "...occur based on maturity of the relevant technical baseline as opposed to calendar milestones.…" If the SDR had disclosed the mass and weight discrepancies with the 606 vehicle configuration, then the 606 vehicle would probably have been the relevant technical baseline. However, the 606 vehicle configuration was not the relevant technical baseline because discrepancies were revealed by the DAC conducted prior to the SDR. The Orion Project Office knew that the 606 vehicle was not the relevant technical baseline and therefore, the SDR should have been delayed.

The Agency has acted in a prudent manner during Phase B and provides further support for the implementation of our recommendation. The pre-PDR DACs continue to show

the vehicle configuration's technical baseline is not at the PDR maturity level. As a result, the Project has delayed its PDR on two different occasions, and is considering delaying the PDR a third time, to ensure that the Project reviews the relevant technical baseline. However, without the Agency taking the necessary step to revise NPR 7123.1A to require that technical products incorporate known changes resulting from analysis cycles, there is a risk that life-cycle reviews could again be performed on premature configurations. Therefore, we request that the Chief Engineer reconsider his position and provide additional comments with regard to requiring projects to update the life-cycle review's technical products with known changes to the technical baseline resulting from engineering analysis cycle assessments.

Recommendation 2.a. The Associate Administrator for Exploration Systems Mission Directorate should evaluate the 607 vehicle configuration for assurance that it was assessed at a minimum of the SDR level and, if not, determine the impact for any affected systems and, if material, perform an SDR on that part.

Management's Response. The Associate Administrator for Exploration Systems Mission Directorate nonconcurred, stating that no additional review is warranted. He stated that the configuration changes involved extensive participation and review by the entire community of technical subject matter experts and stakeholders from across the Agency. In addition, the community assessed the results against the SDR success criteria and identified actions to revise requirements, risks, etc. The Orion Project reviewed the 607 vehicle configuration with the CxP, the Exploration Systems Mission Directorate, the Agency independent technical authorities, the Standing Review Board, and the Administrator. The Orion Project and the Standing Review Board presented the results at the Key Decision Point B meeting in April 2008. The Associate Administrator also stated, as noted in the OIG report, that NASA did not begin Phase B tasks until the 607 configuration was defined.

Evaluation of Management's Response. Although the Associate Administrator nonconcurred, his comments are responsive to the intent of our recommendation. In his response, the Associate Administrator stated that the Agency is in strong agreement that adhering to the discipline of the life-cycle development approach is vital and that the purpose of any life-cycle review is to provide complete and objective information to Agency management. The Associate Administrator also stated that the 607 vehicle configuration that proceeded to Phase B was extensively reviewed by the Project, CxP, Exploration Systems Mission Directorate, independent technical authorities, and the Standing Review Board who all came to the conclusion to proceed to Phase B.

Although the 607 vehicle configuration did not proceed through a formal SDR process, namely the configuration did not benefit from the rigors of the RID process, we agree that the configuration changes were eventually reviewed by technical subject matter experts and Agency stakeholders. Furthermore, the Agency has delayed the PDR because the known technical baseline changes are not at the proper maturity level and

those changes will obtain the full rigors of the PDR process. Therefore, we consider the recommendation resolved and closed.

Recommendation 2.b. The Associate Administrator for Exploration Systems Mission Directorate should ensure that the contractor receives future award fees based on achieving the expected technological maturity level required at a particular milestone as opposed to convening and prematurely conducting a scheduled review at that milestone.

Management's Response. The Associate Administrator for Exploration Systems Mission Directorate concurred stating that NASA acted in accordance with the recommendation in the case of the first Orion award fee period. He stated that the award fee period associated with this milestone had no bearing on scheduling the SDR review or in the technical evaluation of the SDR products. The award fee approach for Orion was successful in that the evaluation took place at a logical point in development of products at the end of a DAC. Based on the quality of the delivered products, the performance of the contractor was assessed for all activities in that period against the established criteria. A weakness was included for the first award fee period relative to the contractor's inability to adequately manage and track mass through DAC-1. This was a clear indicator the contractor was not meeting technical or management maturity expectations at that time. NASA has extended award fee period two in order to accommodate programmatic changes and to assure the period maintains the original intent, which is to evaluate expected performance and maturity to be demonstrated at the Pad Abort 1 test and the PDR milestones.

Evaluation of Management's Response. The Associate Administrator's comments are generally responsive to our recommendation. Although we were able to verify that a weakness was noted for the contractor's inability to adequately manage and track mass, we disagree that NASA acted in accordance with the recommendation during award fee period one in that the SDR did not review the appropriate vehicle configuration nor meet the SDR success criteria. However, the actions taken during award fee period two demonstrate that NASA has acted in accordance with the intent of our recommendation by adjusting the milestone period to coincide with the delayed PDR. Therefore, we consider the recommendation resolved and closed.

APPENDIX A

Scope and Methodology

We performed this audit from June 2007 through October 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. We performed audit fieldwork at NASA Headquarters and Johnson Space Center (Johnson).

To assess the effectiveness of NASA's Orion acquisition management, we reviewed and analyzed NASA's efforts to transition Orion from the "Concept and Technology Development" phase (Phase A) to the "Preliminary Design and Technology Completion" phase (Phase B). We focused on Phase A's life-cycle processes to include the SRR, SDR, and PNAR. We also reviewed internal controls as they related to the overall objective. We issued a report related to the audit objectives that concerned the establishment and operation of the SRB.

During our pre-audit planning, the Project Office allowed us to observe the SRR process at Johnson. We observed the SRR, in March 2007, and the SDR in August 2007. We also attended the Project Office's SDR/PNAR briefings to the SRB in December 2007 and the SRB's out-briefing to the Integrated Center Management Council in February 2008.

We interviewed personnel from the Exploration Systems Mission Directorate, CxP, and the Project Office at NASA Headquarters and Johnson to discuss the overall process used in the acquisition of Orion. We also interviewed:

- NASA Headquarters officials from the Office of the Chief Engineer responsible for the policy and guidance. We discussed their approach in updating NPRs 7120 and 7123 and the entrance and success criteria used during the SRR and SDR milestone reviews.

- Engineering, Safety and Mission Assurance, and Health and Medical, Technical Authorities that are matrixed to the Orion Project to discuss their processes of ensuring visibility and timely communications within the Project Office and to understand their role in the SRR and SDR milestone reviews.

- Johnson contracting officials to discuss the development and selection of the prime contractor for Orion and the evaluation of the contractor award fees.

- Orion Project Officials to discuss the flow down of the requirements from CxP to Lockheed for functional elements and subsystems.

In addition to reviewing NPR 7120.5D, "NASA Space Flight Program and Project Management Requirements," March 6, 2007, and NPR 7123.1A, "NASA Systems Engineering Processes and Requirements," March 26, 2007, we also reviewed NASA Policy Directive 1000.0, "Strategic Management Governance Handbook," August 30, 2005; NPR 7123.1, "NASA Systems Engineering Processes and Requirements," March 13, 2006; and "Program and Project Formulation Document," July 7, 2006.

We also reviewed other documents concerning the management and development of Orion:

- CxP 70003, "Constellation Program Plan," September 28, 2006;
- CxP 70006, "Constellation Program, Crew Exploration Vehicle SRR Process Plan," Revision A, Change 001, May 17, 2007;
- CxP 70006, Annex 2.2, "Constellation Program, Crew Exploration Vehicle SRR Process Plan," Revision A, Change 001, May 17, 2007;
- CxP 70016, "Constellation Program Requirements Management Plan," Change 1, May 17, 2007;
- CxP 72008, "Crew Exploration Vehicle Project Plan," Draft, Draft Maturity (80%), December 18, 2006;
- CxP 72088, "Crew Exploration Vehicle, Systems Engineering Management Plan," November 8, 2006 and Revision A, July 10, 2007;
- CxP 72091, "Crew Exploration Vehicle Risk Management Plan," September 18, 2006;
- CxP 72097, "Crew Exploration Vehicle Master Verification Plan," March 1, 2007; and
- CxP 72107, "Crew Exploration Vehicle, System Definition Review, Process Plan," June 22, 2007.

Further, we reviewed internal and external reports and documents relating to Orion Project management:

- Report of the Commission on the Implementation of U.S. Space Exploration Policy, "A Journey to Inspire, Innovate, and Discover" June 2004;

- "NASA Exploration Systems Architecture Study," November 2005;
- "NASA Award Fee Process," November 1, 2006;
- ZV-07-005, "Preliminary Design Review Point of Departure Definition Activity," June 8, 2007;
- "SRR Review Item Discrepancy Database," as of August 3, 2007;
- "CEV Contract Award Fee Evaluation Plan," August 27, 2007; and
- "SRR Action Closeout Summary," as of September 10, 2007.

Computer-Processed Data. We did not perform a detailed assessment on the reliability and validity of the SRR Review Item Discrepancy (RID) database or the SRR Action Closeout Summary Report. We used the database to verify that all RIDS were dispositioned and to reconcile differences between the database and the RIDs the Project reported as reviewed. However, we did not verify that the database was all-inclusive. We used the Action Closeout Report to verify that all actions assigned to responsible parties had been dispositioned, but we did not verify that the report included every action. However, changes in the number of RIDs in the database or actions in the report would not change our conclusions or recommendations.

Review of Internal Controls

We reviewed the internal controls associated with project life-cycle management. The Project Office performed the required assessments for the SRR and the SDR to determine if Orion was ready to proceed to the next life-cycle phase. Additionally, the SRB assessed the life-cycle reviews. However, the Project Office proceeded through the SDR milestone knowing that the vehicle configuration was not at the appropriate maturity level. Until the Project can provide assurance that the appropriate vehicle design is the one reviewed, we cannot place full reliance on the life-cycle processes. We discussed the internal control deficiency within the body of this report. Implementing the recommendation in this report should improve the internal controls over life-cycle project management.

Prior Coverage

During the last 6 years, GAO and the NASA Office of Inspector General have issued five reports on NASA's acquisition process. Unrestricted reports can be accessed over the Internet at http://www.gao.gov (GAO) and http://www.hq.nasa.gov/office/oig/hq/audits/reports/FY07/index.html (NASA).

Government Accountability Office

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

The report discussed challenges NASA is facing in developing the systems to achieve its goals for the President's Vision for Space Exploration. The report focused on the Ares I Crew Launch Vehicle and the Orion because NASA is currently working toward PDR. The report states that there are considerable unknowns as to whether NASA's plans for these vehicles can be executed within cost and schedule. NASA is still in the process of defining many performance requirements and such uncertainties could affect the mass, loads, and weight requirements for the vehicles. The upcoming PDR represents the most critical juncture where hard decisions can be made as to whether the programs should proceed forward.

"Agency Has Taken Steps Toward Making Sound Investment Decisions for Ares I but Still Faces Challenging Knowledge Gaps" (GAO-08-051, October 31, 2007)

The report, which discusses NASA's efforts to implement the President's plan to return humans to the moon and prepare for eventual human space flight to Mars, is the development of the Ares I Crew Launch Vehicle. NASA plans to conduct the first human space flight in 2015. The report also states that the agency is seeking to speed development efforts in order to reduce the gap in our nation's ability to provide human access to space caused by the Space Shuttle's retirement in 2010. There are gaps in knowledge about requirements, costs, schedule, technology, design, and production feasibility. These gaps are significant and challenging given the complexity and interdependencies in the program.

"NASA: Long-Term Commitment to and Investment in Space Exploration Program Requires More Knowledge" (GAO-06-817R, July 17, 2006)

The report, which discusses NASA's status on implementing the President's Vision for Space Exploration, states that although NASA is continuing to refine its exploration architecture cost estimates, the Agency cannot provide a firm estimate of what it will take to implement the architecture. In addition, the report states that NASA will be challenged to implement the exploration architecture with its projected budget. The report also discusses NASA's acquisition strategy for the Crew Exploration Vehicle and states the strategy places the Project at risk for cost overruns, schedule delays, and performance shortfalls.

"NASA-Implementing a Knowledge-Based Acquisition Framework Could Lead to Better Investment Decisions and Project Outcomes" (GAO-06-218, December 21, 2005)

The report discusses NASA's revised policy for developing flight systems and ground support projects incorporates some of the best practices used by successful

developers. By not establishing a minimum threshold for technology maturity, NASA increases the risk that design changes will be required later in development, when such changes are typically more costly to make. In addition, although NASA's policy does require project managers to establish a continuum of technical and management reviews, it does not specify what these reviews should be, nor does it require major decision reviews at other key points in a product's development. Acquiring knowledge at key junctures will become increasingly important as NASA proceeds to implement elements of the *Vision*. Without a major decision review at key milestones to ensure that the appropriate level of knowledge has been achieved to proceed to the next phase, the risk of cost and schedule overruns, as well as performance shortfalls, increases.

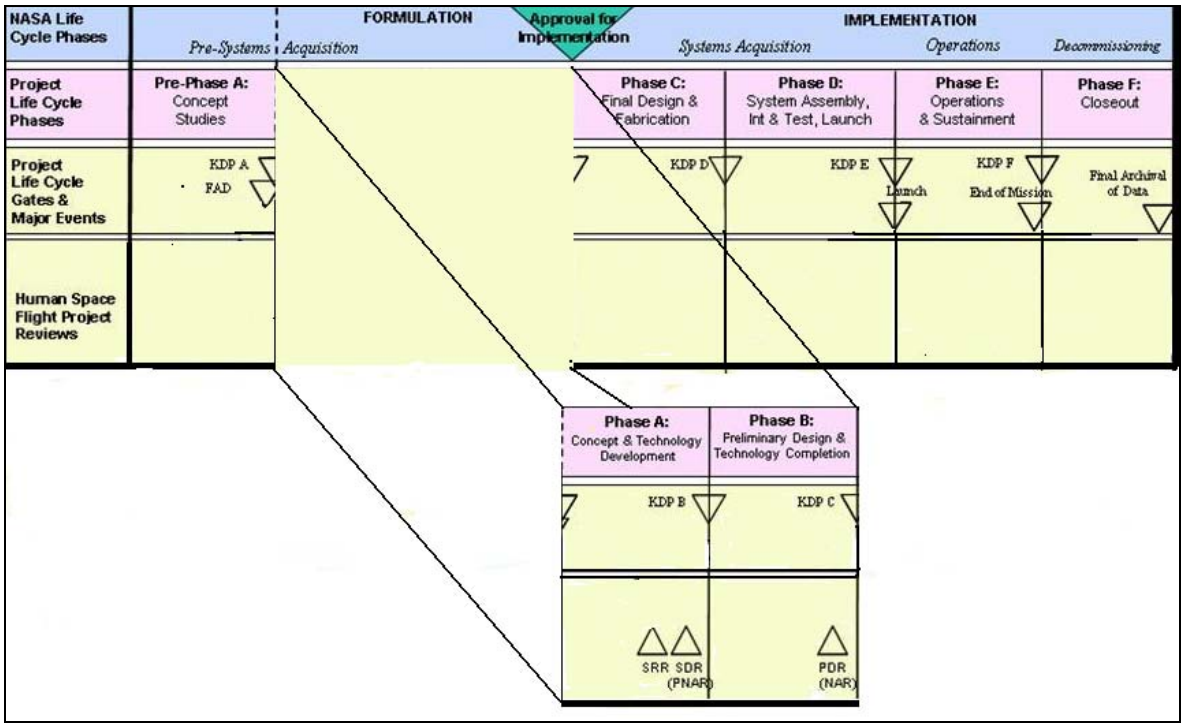
National Aeronautics and Space Administration Office of Inspector General

"Acquisition of the Space Station Propulsion Module" (IG-01-027, May 21, 2001)

The report, which discusses the Acquisition of the Space Station Propulsion Module, states the Propulsion Module was not cost effective. In addition, NASA implemented the United States Propulsion Module design before properly accomplishing acquisition planning and preparing project documents. Specifically, NASA did not validate requirements from the SRR before beginning a PDR of the propulsion module; Agency pursued implementation of the propulsion system without an approved project plan or risk management plan; and NASA selected The Boeing Company as the sole-source contractor without properly documenting the justification for the noncompetitive selection.

LIFE CYCLE OF A NASA SPACE FLIGHT PROJECT

The following figure shows the complete life cycle of a NASA space flight project. Our audit of the Orion Project focused primarily on Phases A and B of the life cycle.



Source: NPR 7120.5D (figure 2-4)

Acronyms

FAD	Formulation Authorization Document
KDP	Key Decision Point (for the Orion, KDP B was held on April 29, 2008)
NAR	Non-Advocate Review
PDR	Preliminary Design Review
PNAR	Preliminary Non-Advocate Review (for Orion, completion of the PNAR was April 29, 2008)
SDR	System Definition Review
SRR	System Requirements Review

SYSTEM REQUIREMENTS REVIEW ENTRANCE / SUCCESS CRITERIA

System Requirements Review	
Entrance Criteria	**Success Criteria**
1. Successful completion of the MCR and responses made to all MCR Requests for Actions (RFAs) and Review Item Discrepancies (RIDs). 2. A preliminary SRR agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the SRR. 3. The following technical products for hardware and software system elements are available to the cognizant participants prior to the review: a. system requirements document; b. system software functionality description; c. updated concept of operations; d. updated mission requirements, if applicable; e. baselined SEMP; f. risk management plan; g. preliminary system requirements allocation to the next lower level system; h. updated cost estimate; i. Technology Development Maturity Assessment Plan; j. updated risk assessment and mitigations (including PRA as applicable). k. logistics documentation (e.g., preliminary maintenance plan); l. preliminary human rating plan, if applicable; m. Software Development Plan (SDP); n. system safety and mission assurance plan; o. configuration management plan; p. initial document tree; q. verification and validation approach; r. preliminary system safety analysis; and s. other specialty disciplines, as required.	1. The project utilizes a sound process for the allocation and control of requirements throughout all levels, and a plan has been defined to complete the definition activity within schedule constraints. 2. Requirements definition is complete with respect to top-level mission and science requirements, and interfaces with external entities and between major internal elements have been defined. 3. Requirements allocation and flow down of key driving requirements have been defined down to subsystems. 4. Preliminary approaches have been determined for how requirements will be verified and validated down to the subsystem level. 5. Major risks have been identified and technically assessed, and viable mitigation strategies have been defined.

Source: NPR 7123.1A (Table G-4)

The SRR examines the functional and performance requirements defined for the system and the preliminary program or project plan and ensures that the requirements and the selected concept will satisfy the mission.

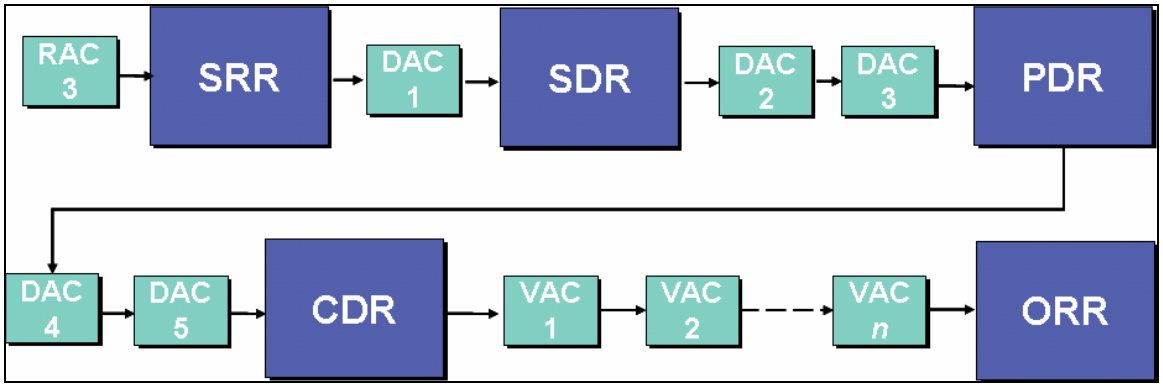
SYSTEM DEFINITION REVIEW ENTRANCE / SUCCESS CRITERIA

System Definition Review	
Entrance Criteria	**Success Criteria**
1. Successful completion of the SRR and responses made to all SRR RFAs and RIDs. 2. A preliminary SDR agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the SDR. 3. SDR technical products listed below for both hardware and software system elements have been made available to the cognizant participants prior to the review: a. system architecture; b. preferred system solution definition including major tradeoffs and options; c. updated baselined documentation, as required; d. preliminary functional baseline (with supporting trade-off analyses and data); e. preliminary system software functional requirements; f. SEMP changes, if any; g. updated risk management plan; h. updated risk assessment and mitigations (including PRA, as applicable); i. updated technology development, maturity, and assessment plan; j. updated cost and schedule data; k. updated logistics documentation; l. based on system complexity, updated human rating plan; m. software test plan; n. software requirements document(s); o. interface requirements documents (including software); p. technical resource utilization estimates and margins; q. updated safety and mission assurance (S&MA) plan; and r. updated preliminary safety analysis.	1. Systems requirements, including mission success criteria and any sponsor-imposed constraints, are defined and form the basis for the proposed conceptual design. 2. All technical requirements are allocated and the flow down to subsystems is adequate. The requirements, design approaches, and conceptual design will fulfill the mission needs consistent with the available resources (cost, schedule, mass, and power). 3. The requirements process is sound and can reasonably be expected to continue to identify and flow detailed requirements in a manner timely for development. 4. The technical approach is credible and responsive to the identified requirements. 5. Technical plans have been updated, as necessary. 6. The tradeoffs are completed, and those planned for Phase B adequately address the option space. 7. Significant development, mission, and safety risks are identified and technically assessed, and a process and resources exist to manage the risks. 8. Adequate planning exists for the development of any enabling new technology. 9. The operations concept is consistent with proposed design concept(s) and is in alignment with the mission requirements.

Source: NPR 7123.1A (Table G-6)

The SDR examines the proposed system architecture and design and the flow down to all functional elements of the system.

ORION'S ANALYSIS CYCLES PERFORMED BETWEEN LIFE-CYCLE REVIEWS



Source: CxP 72088, "Crew Exploration Systems Engineering Management Plan," Figure 5.4-1

Orion's integrated analysis reviews comprise three major analysis cycles that progressively support definition, design, verification, and readiness, through the operational readiness review.

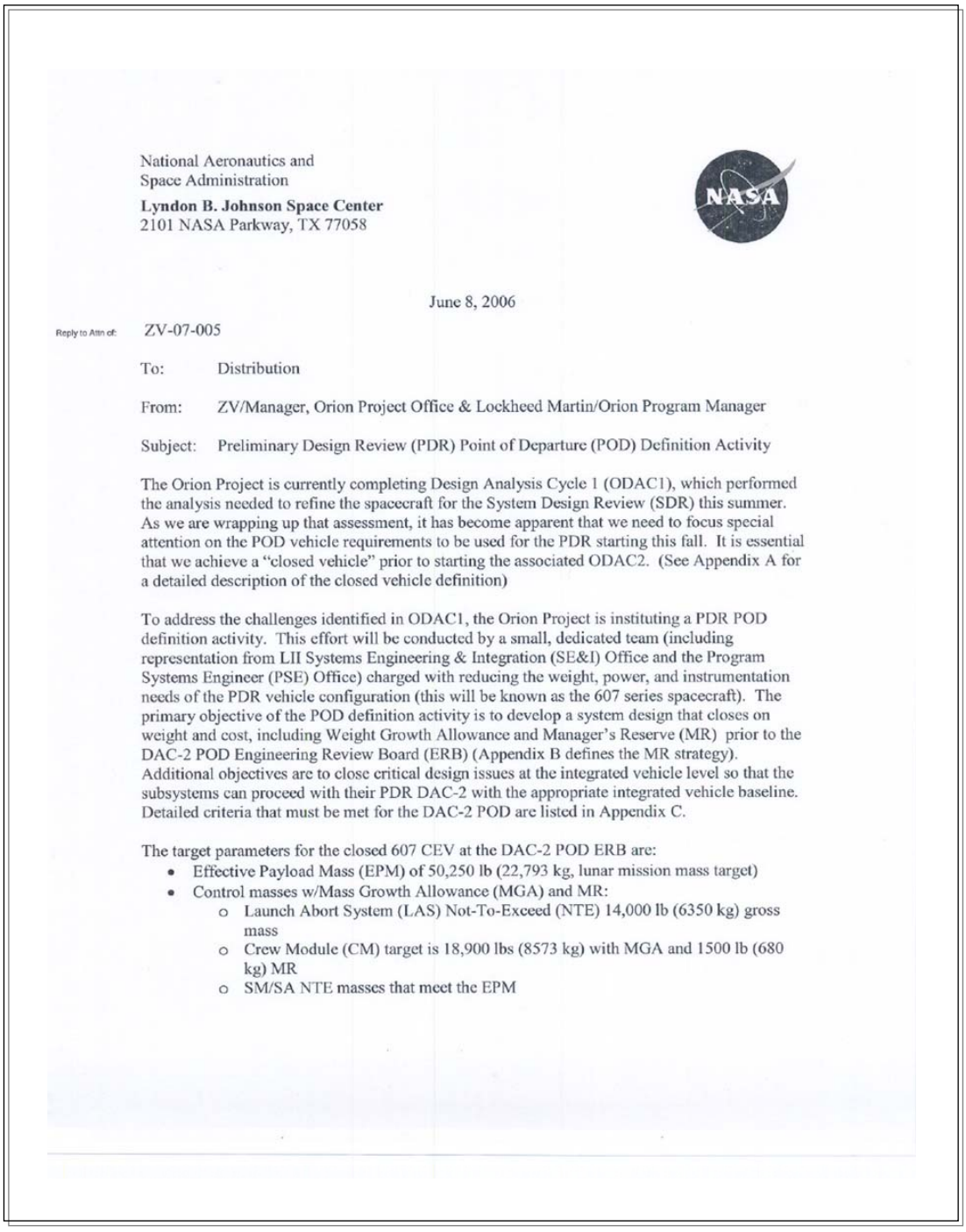
Analysis Cycle Acronyms/Definitions

RAC Requirements Analysis Cycle - Supports the analysis and trades performed early in the life cycle to develop and validate technical requirements.

DAC Design Analysis Cycle - Directly supports achievement of the goals of the next design review including the SDR, PDR, and CDR (Critical Design Review).

VAC Verification Analysis Cycle - Supports the achievement of overall readiness in time for the ORR (Operational Readiness Review).

PRELIMINARY DESIGN REVIEW DEFINITION ACTIVITY MEMORANDUM



National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
2101 NASA Parkway, TX 77058

June 8, 2006

Reply to Attn of: ZV-07-005

To: Distribution

From: ZV/Manager, Orion Project Office & Lockheed Martin/Orion Program Manager

Subject: Preliminary Design Review (PDR) Point of Departure (POD) Definition Activity

The Orion Project is currently completing Design Analysis Cycle 1 (ODAC1), which performed the analysis needed to refine the spacecraft for the System Design Review (SDR) this summer. As we are wrapping up that assessment, it has become apparent that we need to focus special attention on the POD vehicle requirements to be used for the PDR starting this fall. It is essential that we achieve a "closed vehicle" prior to starting the associated ODAC2. (See Appendix A for a detailed description of the closed vehicle definition)

To address the challenges identified in ODAC1, the Orion Project is instituting a PDR POD definition activity. This effort will be conducted by a small, dedicated team (including representation from LII Systems Engineering & Integration (SE&I) Office and the Program Systems Engineer (PSE) Office) charged with reducing the weight, power, and instrumentation needs of the PDR vehicle configuration (this will be known as the 607 series spacecraft). The primary objective of the POD definition activity is to develop a system design that closes on weight and cost, including Weight Growth Allowance and Manager's Reserve (MR) prior to the DAC-2 POD Engineering Review Board (ERB) (Appendix B defines the MR strategy). Additional objectives are to close critical design issues at the integrated vehicle level so that the subsystems can proceed with their PDR DAC-2 with the appropriate integrated vehicle baseline. Detailed criteria that must be met for the DAC-2 POD are listed in Appendix C.

The target parameters for the closed 607 CEV at the DAC-2 POD ERB are:

- Effective Payload Mass (EPM) of 50,250 lb (22,793 kg, lunar mission mass target)
- Control masses w/Mass Growth Allowance (MGA) and MR:
  - Launch Abort System (LAS) Not-To-Exceed (NTE) 14,000 lb (6350 kg) gross mass
  - Crew Module (CM) target is 18,900 lbs (8573 kg) with MGA and 1500 lb (680 kg) MR
  - SM/SA NTE masses that meet the EPM

ZV-07-005

The strategy of the POD definition activity will require three fundamental assessments: a vehicle foundation assessment, subsystem reviews and analysis, and risk balancing (all described later in this letter). Components and functions not absolutely vital to the lunar mission will be stripped out and placed into a holding area we are calling the "parking lot" to create a minimum functionality vehicle. Items placed into the parking lot will be added back to the vehicle in a strategic manner, prioritized to meet safety, robustness, and mission objectives, up to the weight, power, and thermal margins needed to achieve the closed vehicle definition.

The vehicle foundation assessment will review design loads, trajectories, and aero/aerothermal analysis to ensure consistency of ground rules, assumptions, and uncertainty factors, and to look for relief that can benefit the structures, mechanisms, Thermal Protection System (TPS), and LAS subsystems. The subsystem reviews will evaluate the subsystem architecture, component selection, and rationale, and includes reducing fault tolerance to one-fault tolerant for safety critical failures and zero-fault tolerant for mission critical failures. Risk balancing is a systems engineering process which will provide an assessment of the safety and reliability of the minimum functionality vehicle, and develop reliability models and tools that can be used to buy back items from the parking lot in an informed manner. If additional performance is available after the completion of the risk balancing activity, additional vehicle functionality will be added back as prioritized by project management.

While this POD definition activity is broad reaching, there are a few items considered off limits. These include the Outer Mold Line (OML) size and shape, and the crew complement (6 crew to ISS and 4 crew to Lunar). In addition, changes to subsystem basic technology or architecture (i.e., amine swing beds v. LiO canisters, Low Impact Docking Systems (LIDS) vs. probe and cone) will not be addressed unless the vehicle can not be closed with sufficient reliability and functionality. Systems will be reviewed for basic efficacy to ensure the appropriate system has been selected for the Orion mission. Significant reductions in Orion functional requirements may result in re-architecting select systems for improved mass and power performance, or reduced complexity.

The POD definition effort will be led by the NASA Orion Vehicle Integration Office (VIO), and the Lockheed Martin Systems Engineering and Integration Team (SEIT). The day-to-day POD definition activities will be led by the Orion Vehicle Engineering Integrated Working Group (OVEIWG). The OVEIWG will report out to the CICP each Friday. The POD definition was kicked-off at the 6/8/07 CICP with the approval of the ground rules and assumptions, the broad schedule including the dates for the first subsystem reviews, and the initial parking lot.

Caris A. Hatfield
Manger, Orion Project Office
Johnson Space Center

1. Cleon Lacefield

Cleon Lacefield
Manager, Orion Program
Lockheed Martin

ZV-07-005

Appendix A – Definition of closed vehicle

For the DAC-2 POD ERB, the closed 607 Crew Exploration Vehicle (CEV) shall be defined in terms of both mass and power as follows:
Mass closure:

- Basic Engineering estimate of vehicle weight plus an allocated MGA (predicted) defined by the Orion Mass Properties Control Plan MGA depletion schedule plus 2,000 lb MR or Sufficient MR to cover the weighted estimate of threats and opportunities list, whichever is greater. (See Appendix B for methodology.)

Power closure:

- A closed vehicle for power is defined as positive power margin for all defined mission modes and states.
- Positive power margin is defined to include a flight performance reserve of 10% and a power growth allowance based on the maturity of each of the loads and the guidelines contained in American Institute of Aeronautics and Astronautics (AIAA)-G-020-1992.
- For DAC-2, the applicable section of the Pressure Garment Assembly (PGA) table is "CoDR Class", which is an average PGA of ~ 15%
- One failure shall not cause the loss of mission, and any two failures shall not cause loss of crew (power shedding strategies that enable safe crew return are acceptable.)
- Bus voltage shall comply with the power quality specification.
- Power profiles shall reflect component current best estimate power (not spec NTE values, no extra margin) + PGA + 10% performance reserve, and be based on modeled voltage, worst-case solar collection conditions, and worst-case load timelines.
- CEV must maintain self-consistency in thermal loads for these driving case timelines.
- In considering power loads, minimum duty cycles to achieve mission objectives will be used to define the vehicle power load by mission phase.

Sensors:

- Special attention will be given to the number of sensors and vehicle telemetry with a focus on minimizing the number required.

ZV-07-005

Appendix B – MR Strategy

The spacecraft MR shall be 2,000 lb or sufficient MR to cover the weighted estimate of threats and opportunities list whichever is greater. The weighted estimating technique shall consist of using system experts to provide a best estimate of the weight impact associated with the threat or opportunity, and assess on a scale of 1-5 the likelihood of incorporation of the threat or opportunity. The scale is listed below:

1 = just thought of it; believed that it is potentially an issue/opportunity; value is based on engineering judgment; 20% of mass is incorporated in sum

2 = preliminary assessment indicates it may be issue/opportunity; number scaled or parametric; 40% of mass threat is incorporated in sum

3 = assessment indicates a likely issue/opportunity; number based on prelim analysis; 60% of mass threat is incorporated in sum

4 - analysis to date indicates required or available, but more analysis is needed to confirm specific number; 80% of mass threat is incorporated in sum

5 - it's a certainty that is needed or can be done, just has not made it to the Mandatory Evaluation List (MEL) yet; 100% of mass threat is incorporated in sum

The weighted estimate is simply the best estimate of weight impact associated with a threat or opportunity multiplied by the likelihood of incorporation.

ZV-07-005
Appendix C – DAC-2 POD Criteria

Criteria needed for the DAC-2 POD includes:

- Baseline Requirements Package (w/ Errata as required)
- Vehicle Design and Conops that closes on Mass (See Appendix A)
- Subsystem Mass Allocations reflecting above
- Center of Gravity that meets L/D derived requirement (self consistent, "fly-able")
- Module layouts meeting minimum separation distances and adequate Crew Volume
- Subsystem Power Allocations within CEV Power/Thermal capability (See Appendix A)
- Achievable design solutions that meet the mass and power allocations
- Subsystem Instrumentation Allocations within the Avionics capabilities of the Vehicle
- Integrated Vehicle fault management/fault detection, isolation and recovery capabilities
- Approved ascent OML and plan forward to obtain test data to confirm vibro-acoustic levels & controllability
- Approved Block Upgrade Plan, including criteria for overall maturity at PDR (spec's that include upgrade hooks and scars, drawing trees that include block upgrades)

DAC-2 POD products include:

- Integrated Vehicle Engineering Products
  - Mass Allocations
  - Power/Thermal Allocations
  - Instrumentation Allocations
  - OML
  - Vehicle Computer Aided Design models
  - Selected Aero databases
  - Selected Loads book
  - Selected Traj database
- Vehicle/Subsystem Design packages reflecting weight reduction decisions
- Block Strategy plan

MANAGEMENT COMMENTS

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

October 10, 2008

Reply to Attn of: Exploration Systems Mission Directorate

TO: Assistant Inspector General for Auditing

FROM: Associate Administrator for Exploration Systems Mission Directorate

SUBJECT: Response to Draft Audit Report "More Stringent Entrance Criteria Needed for Project Life-Cycle Reviews" (Assignment No. A-07-011-01)

NASA appreciates the opportunity to comment to the Draft Audit Report "More Stringent Entrance Criteria Needed for Project Life-Cycle Reviews," which pertains to the Orion Project within the Constellation Systems Program. In response to each of the recommendations contained in the report, we have developed the following responses:

OIG Recommendation 1 - The Chief Engineer should revise NPR 7123.1A's internal life-cycle reviews' entrance criteria to require the project to update the life-cycle review's technical products with known changes to the technical baseline resulting from engineering analysis cycle assessments.

NASA Response to Recommendation 1 - NASA Management does not concur with this recommendation. While the intent of the recommendation is understood, the actual events show that the current policy is effective. The members of the Agency Program Management Council (APMC) reviewed the results of the Orion Systems Definition Review (SDR)/ Preliminary Non-Advocate Review (PNAR). The APMC determined that the SDR/PNAR milestone was successfully completed and the necessary information was provided to the NASA Associate Administrator Decision Authority to determine approval for the Orion project to move into the next phase of the life cycle. In addition, Agency management was made aware of the issues in reviewing an evolving design early in the SDR cycle of reviews. Management approved the strategy of executing the SDR activities and coupling them with an additional "Point of Departure" review to fully inform the Agency decision process and ensure a sound basis for beginning Phase B.

Specifically, the OIG states in the report, Orion met the entrance criteria for SDR. Under entrance criteria number 3 (technical products to be made available to the cognizant review team); the first two items are a) system architecture and b) preferred system solution definition including major tradeoffs and options. Most of the other technical products required at this early life cycle review are plans (risk management, system engineering management, etc.). One must not lose sight of the fact that SDR examines the proposed requirements, the system architecture, and the flow down of requirements to all functional elements of the system. While one aspect of SDR is to review the system

architecture and a preferred system solution definition (not design), a large part of the review is to look at the flow down of requirements to functional elements as well as to review the multitude of plans required at this stage of the life cycle. There is no technical baseline of the design at this point in the life cycle. Trade studies, technology maturation, etc. are still occurring such that by the Preliminary Design Review (PDR), a preliminary design is in place that meets all system requirements with acceptable risk and within the cost and schedule constraints. PDR shows that the correct design option has been selected.

OIG Recommendation 2 – The Associate Administrator for Exploration Systems Mission Directorate should:

a. Evaluate the 607 vehicle configuration for assurance that it was assessed at a minimum of the SDR level and, if not, determine the impact for any affected systems and, if material, perform an SDR on that part.

b. Ensure that the contractor receives future award fees based on achieving the expected technological maturity level required at a particular milestone as opposed to convening and prematurely conducting a schedule review at that milestone.

NASA Response to Recommendation 2a – NASA management does not concur with this recommendation. The agency is in strong agreement that adhering to the discipline of the life cycle development approach is vital to the collective success of the agency. The purpose of any life cycle review is to provide complete and objective information to agency management for informed programmatic and strategic decision making.

The Orion 607 configuration represents one point in the continuing evolution of the Orion system definition. Each specific configuration establishes a set of design parameters to be used by the team during a Design Analysis Cycle (DAC). The configurations will continue to mature through the definition of a Preliminary Design at PDR and final design at the Critical Design Review (CDR). The development of the Orion 607 configuration was based directly on the outcome of the pre-SDR DAC results and was directed to conclusion by the formal decisions made at the SDR Board in August 2007. The SDR Board was successful in identifying the full set of criteria shortfalls required and was very specific about directing the work required and technical criteria to be satisfied prior to initiating any Phase B preliminary design activity. The configuration changes involved extensive participation and review by the entire community of technical subject matter experts and stakeholders from across the agency.

In addition, the community assessed the results against the SDR success criteria and identified actions to revise requirements, risks, etc. as needed. The Orion Project reviewed the 607 vehicle configuration with the Constellation Program, the Exploration Systems Mission Directorate, the agency independent technical authorities, the Standing Review Board, and the Administrator prior to base lining it as the Phase B Point of Departure (POD) conceptual design in November 2007. In addition, the Standing

Review Board performed an in-depth review of the 607 configuration and concluded the project was ready to proceed to PDR. The Orion Project and the Standing Review Board presented the results of this analysis at the Key Decision Point B (KDP-B) meeting with Senior Agency leaders, including the NASA Administrator in April 2008. As noted in the OIG report, NASA did not begin Phase B tasks until the 607 configuration was defined. In its oversight of the process and review of the results, ESMD management is satisfied that the management and technical processes defined in Agency policy for the Orion SDR/PNAR were adhered to and worked as designed to be adaptive and rigorous in addressing the criteria. Therefore, we believe no additional review is warranted.

NASA Response to Recommendation 2b –NASA agrees and acted in accordance with this recommendation in the case of the first Orion Award fee period covered in this audit. The fact that there was a possible award fee period associated with this milestone had no bearing on scheduling the review or in the technical evaluation of the SDR products. For most NASA contracts, award fee periods are defined as specific blocks of time rather than being associated with specific milestones. Orion and other ESMD contracts established this approach, in order to conduct a more complete evaluation using the products delivered at a milestone. This is preferable to defining an award fee period as an arbitrary block of time (for example, many contracts use award fee periods that are 6 months long) where the contractor is evaluated on work that is only partially complete, making the evaluation much more difficult. The contract award fee approach for Orion was successful in that the evaluation took place at a logical point in the development of products at the end of a DAC.

The Orion award fee plan establishes the evaluation criteria used by NASA to conduct each award fee period evaluation. The review milestone is used to identify the completion of a period because it drives the completion and delivery of products to the government. Based on the quality of the delivered products, the performance of the contractor is assessed of all activities in that period against the established criteria. The Performance Evaluation Board (PEB) evaluates performance of all objectives (including maturity level required for a milestone) and determines the score for the period. A weakness was included for the first award fee period relative to the contractor's inability to adequately manage and track mass through DAC 1 – a clear indication the contractor was not meeting technical or management maturity expectations at that time. NASA also has extended award fee period two, to accommodate programmatic changes (funding and schedule) and to assure the period maintains the original intent to evaluate expected performance and maturity to be demonstrated at the Pad Abort 1 (PA1) test and PDR milestones. NASA will, however, continue to provide periodic interim performance feedback to the contractor to ensure that focus remains on excellent performance. The Areas of Emphasis (AOE) have also been updated to reflect the latest priorities of the project.

The award fee plan for the Orion contract is a performance based structure with the end of the periods tied to specific milestones. The fee awarded for period one was determined by the Fee Determination Official (FDO) based on inputs provided by the PEB and PEB-Integration Team. The performance score for this period was determined

by all activities and milestones contained in the period. Although the contract specifically identifies fee dollars for performance milestones in each award fee period, these interim fee amounts are collectively subject to a final evaluation at the end of the contract. For each interim milestone and the final evaluation the contractor is evaluated based on criteria established in the award fee plan as well as the AOE provided by NASA. The grading criteria are grouped into technical, program management, cost management, and small business/small disadvantaged business categories. Among these are criteria in which we can judge maturity such as performance, safety and mission assurance, requirements, risk management and margin management.

The Orion Project will continue to follow this approach to performance based award fee management throughout the contract period of performance.

If you have any questions about this response, please contact Marcietta Washington at marcietta.s.washington@nasa.gov or 202-358-4427

R. Gilbrech
Richard Gilbrech
Associate Administrator

10-10-08
Date

Michael Ryschkewitsch
Michael Ryschkewitsch
NASA Chief Engineer

10/10/08
Date

REPORT DISTRIBUTION

National Aeronautics and Space Administration

Administrator
Deputy Administrator
Chief of Staff
Chief Engineer
Associate Administrator for Explorations Systems Mission Directorate
Constellation Program Manager
Orion Project Manager

Non-NASA Organizations and Individuals

Office of Management and Budget
    Deputy Associate Director, Energy and Science Division
        Branch Chief, Science and Space Programs Branch
Government Accountability Office
    Director, Defense, State, and NASA Financial Management, Office of Financial Management and Assurance
    Director, NASA Issues, Office of Acquisition and Sourcing Management

Congressional Committees and Subcommittees, Chairman and Ranking Member

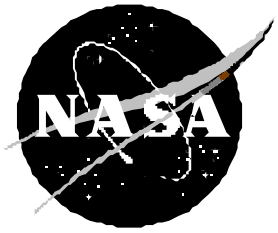
Senate Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies
Senate Committee on Commerce, Science, and Transportation
    Subcommittee on Space, Aeronautics, and Related Sciences
Senate Committee on Homeland Security and Governmental Affairs
House Committee on Appropriations
    Subcommittee on Commerce, Justice, Science, and Related Agencies
House Committee on Oversight and Government Reform
    Subcommittee on Government Management, Organization, and Procurement
House Committee on Science and Technology
    Subcommittee on Investigations and Oversight
    Subcommittee on Space and Aeronautics

Major Contributors to the Report:

Carol Gorman, Director, Space Operations and Exploration Directorate
Ray Tolomeo, Director, Mission Programs and Projects
Loretta Atkinson, Project Manager
Jim Griggs, Team Lead
Douglas Orton, Team Lead
Barbara Moody, Auditor
Eugene Bauer, Auditor
Frank Martin, Aerospace Technologist
Cindy Stein, Aerospace Technologist
Janet Overton, Report Process Manager

OCTOBER 31, 2008

REPORT No. IG-09-004



OFFICE OF AUDITS

OFFICE OF INSPECTOR GENERAL

ADDITIONAL COPIES

Visit http://oig.nasa.gov/audits/reports/FY09 to obtain additional copies of this report, or contact the Assistant Inspector General for Auditing at 202-358-1232.

COMMENTS ON THIS REPORT

In order to help us improve the quality of our products, if you wish to comment on the quality or usefulness of this report, please send your comments to Ms. Jacqueline White, Director of Special Projects and Quality Assurance, at Jacqueline.White@nasa.gov or call 202-358-0203.

SUGGESTIONS FOR FUTURE AUDITS

To suggest ideas for or to request future audits, contact the Assistant Inspector General for Auditing. Ideas and requests can also be mailed to:

Assistant Inspector General for Auditing
NASA Headquarters
Washington, DC 20546-0001

NASA HOTLINE

To report fraud, waste, abuse, or mismanagement, contact the NASA OIG Hotline at 800-424-9183 or 800-535-8134 (TDD). You may also write to the NASA Inspector General, P.O. Box 23089, L'Enfant Plaza Station, Washington, DC 20026, or use http://oig.nasa.gov/hotline.html#form. The identity of each writer and caller can be kept confidential, upon request, to the extent permitted by law.