National Aeronautics and
Space Administration

Office of Inspector General
Washington, DC 20546-0001

May 21, 2009

TO: Associate Administrator, Exploration Systems Mission Directorate
            Chief Safety and Mission Assurance Officer
            Chief Engineer
            Chief Health and Medical Officer
            Program Manager, Constellation Program

FROM: Assistant Inspector General for Auditing

SUBJECT: NASA's Management of Ares I Human-Rating Requirements
            (Report No. IG-09-016; Assignment No. A-09-003-00)

The Office of Inspector General conducted a review to evaluate the management of the
human-rating requirements for the Ares I Project. Specifically, our objectives were to
determine whether NASA had adequately developed the human-rating requirements and
incorporated them into the program and project plans. We also reviewed internal controls
as they related to the overall objective.

We found that the Agency incorporated the human-rating requirements found in NASA
Procedural Requirements (NPR) 8705.2B, "Human-Rating Requirements for Space
Systems," May 6, 2008, in the appropriate documents. We also noted no weaknesses in
internal controls. Accordingly, this final report contains no recommendations.

Development of Human-Rating Requirements. NASA's policy is to protect the health
and safety of humans involved in or exposed to space activities, specifically the public,
crew, passengers, and ground personnel. This policy is implemented through the
application of various NASA directives and standards. In 2007, NASA assembled a
diversified group of astronauts, engineers, safety engineers, flight surgeons, and mission
operations specialists to rewrite NPR 8705.2A, "Human-Rating Requirements for Space
Systems," February 7, 2005. This group reviewed human-rating documents from the last
45 years that were used in the development of Mercury, Gemini, Apollo, Skylab, the
Space Shuttle, and the International Space Station. The lessons learned from these
programs, and information from numerous books and studies, resulted in NPR 8705.2B,
issued May 6, 2008, which defines the human-rated system as follows:

> A human-rated system accommodates the human needs, effectively utilizes human
> capabilities, controls hazards with sufficient certainty to be considered safe for human
> operations, and provides, to the maximum extent practical, the capability to safely
> recover the crew from hazardous situations.

NPR 8705.2B defines and implements the additional processes, procedures, and requirements that NASA must fulfill for all space systems involving humans prior to a system becoming operational and throughout the system's use.

We found that NASA does not consider NPR 8705.2B to be the only criteria a space system must fulfill to be human-rated. In addition to NPR 8705.2B, every space system must meet applicable requirements of numerous mandatory engineering and safety policies and technical standards within the Agency. However, the Aerospace Safety Advisory Panel (ASAP) had expressed concerns because NPR 8705.2B does not provide a direct link to these other applicable requirements. ASAP questioned the substance, application, and standardization of the human-rating requirements NASA-wide. As a result, ASAP recommended that NASA formally establish and stipulate the direct link between the human-rating requirements and the applicable NASA technical standards. NASA is formally responding to the ASAP recommendation and has initiated a revision to the NPR to include references to NASA directives and standards that are mandatory for all space systems. We plan to monitor and review NASA's response to the ASAP recommendation.

Incorporation of Human-Rating Requirements. In 2008, the Office of Safety and Mission Assurance (OSMA) completed a process to determine which safety requirements, including human-rating requirements, were applicable to the Constellation Program (CxP). The NASA Chief Engineer and the Chief Health and Medical Officer also participated in the requirements determination process. OSMA determined that more than 500 safety requirements were applicable to CxP, including all of the human-rating requirements in NPR 8705.2B.

We found that NASA incorporated NPR 8705.2B requirements into the CxP and Ares I Project plans. Compliance with NPR 8705.2B requirements is mandatory for CxP and its seven major projects: Orion Crew Exploration Vehicle, Crew and Cargo Launch Vehicles (Ares I and Ares V), Ground Operations, Mission Operations, Extra-Vehicular Activity Systems, Altair, and the Lunar Surface Systems. CxP will be NASA's first program to certify that its space system is human-rated and is responsible for ensuring that each of the projects incorporates human-rating requirements in its design.
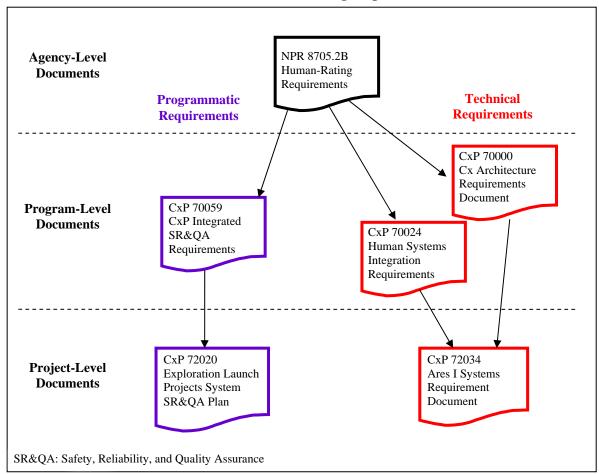
CxP addresses the Agency's human-rating programmatic requirements[1] in CxP 70059, "Constellation Program Integrated Safety, Reliability, and Quality Assurance Requirements," January 9, 2008. Technical requirements[2] are included in CxP 70000, "Constellation Architecture Requirement Document (CARD)," March 15, 2009, and CxP 70024 "Human Systems Integration requirement (HSIR)," March 6, 2009. The following figure shows CxP and Ares I Project documentation incorporating the human-rating requirements. CxP also captures all technical requirements in a database,

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[1] Programmatic requirements are requirements set by the Mission Directorate, program, and project. They include strategic scientific and exploration requirements; system performance requirements; and schedule, cost, and similar non-technical constraints.

[2] Technical requirements, often referred to as product requirements, define what the product must do or a quality that the product must have. Engineering standards would be an example of technical requirements.

Cradle,[3] which manages links between project documents and requirements and tracks revisions to source documents. Technical requirements will subsequently be incorporated into project designs and contractor task orders as systems are developed.

CxP and Ares I Project Documents Incorporating
NPR 8705.2B Human-Rating Requirements

Agency-Level Documents

NPR 8705.2B
Human-Rating
Requirements

Programmatic Requirements

Technical Requirements

Program-Level Documents

CxP 70059
CxP Integrated
SR&QA
Requirements

CxP 70000
Cx Architecture
Requirements
Document

CxP 70024
Human Systems
Integration
Requirements

Project-Level Documents

CxP 72020
Exploration Launch
Projects System
SR&QA Plan

CxP 72034
Ares I Systems
Requirement
Document

SR&QA: Safety, Reliability, and Quality Assurance

For the Ares Project, CxP 72020, "Exploration Launch Projects System Safety, Reliability, and Quality Assurance Plan," August 30, 2006, implements CxP programmatic requirements; CxP 72034, "Ares I Systems Requirement Document, Revision D (SRD)," December 8, 2008, implements CxP technical requirements. In addition to recording the requirement, the SRD describes the verification steps for each requirement to be tested against. The technical requirements in CxP 73024 also apply to the three Ares elements[4] and their respective contractors.

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[3] Cradle also tracks all changes to the requirements, alerts project members to these changes, and monitors the progression of all consequential changes through analysis, design, implementation, test, and acceptance.

[4] The three Ares I elements are (1) First Stage 5-segment Solid Rocket Booster, (2) a cryogenic liquid hydrogen/oxygen-fueled Upper Stage, and (3) a J2-X Upper Stage Engine.

Ares I Project managers provided us with compliance matrices for the human-rating requirements in NPR 8705.2B. We were able to trace the requirements of NPR 8705.2B from CxP to the elements of the Ares I Project and verified that the requirements were incorporated into the appropriate documents.

Scope and Methodology. We performed this audit from January through May 2009 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 the audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

We reviewed NASA, CxP, and Ares I Project documentation related to human-rating requirements. We conducted fieldwork at NASA Headquarters, Johnson Space Center, and Marshall Space Flight Center. We interviewed key personnel at NASA Headquarters within OSMA and the offices of the Chief Engineer and the Chief Health and Medical Officer. We also interviewed personnel within the Johnson Flight Crew Operation Directorate, Johnson and Marshall Safety and Mission Assurance Directorates, and CxP and Ares I Project Offices to gain an understanding of the process of implementing the human-rating requirements of NPR 8705.2B. In addition, we conferred with members of ASAP to gain an understanding of their concerns related to the process of developing the human-rating requirements.

Comments in response to this memorandum are not required. We appreciate the courtesies and cooperation provided during this audit. If you have questions, or need additional information, please contact Mr. Raymond Tolomeo, Science and Aeronautics Research Director, at 202-358-7227.

   signed

Evelyn R. Klemstine

cc:
Project Manager, Ares I