NASA AEROSPACE SAFETY ADVISORY PANEL
National Aeronautics and Space Administration
Washington, DC 20546
VADM Joseph W. Dyer USN, (Ret.), Chair

January 21, 2009

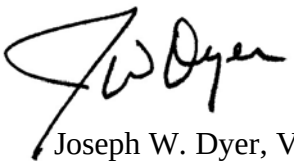
Mr. Christopher Scolese
Acting Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Scolese:

The Aerospace Safety Advisory Panel held its 2008 Fourth Quarterly Meeting at NASA Ames Research Center, Moffett Field, CA, on October 22-23, 2008. We greatly appreciate the support received from NASA subject matter experts.

The Panel submits the enclosed Minutes with Recommendations resulting from this meeting for your consideration.

Sincerely,



Joseph W. Dyer, VADM, USN (Ret.)
Chair

Enclosure

Aerospace Safety Advisory Panel
2008 Fourth Quarterly Report
Minutes and Recommendations

Aerospace Safety Advisory Panel (ASAP)
Public Meeting
October 23, 2008
Ames Research Center
Palo Alto, California

ASAP Members Present

- Vice Admiral Joseph W. Dyer, USN (Retired), Chair
- Dr. James P. Bagian
- Major General Charles F. Bolden, Jr., USMC (Retired)
- Mr. John C. Marshall
- Ms. Joyce A. McDevitt, P.E.

ASAP Staff and Support Personnel Present

- Ms. Katherine Dakon, ASAP Executive Director
- Ms. Susan Burch, ASAP Administrative Officer
- Ms. Sallie Birket Chafer, Reports Editor

OPENING REMARKS

The Aerospace Safety Advisory Panel (ASAP) held the public session of its 2008 fourth quarterly meeting at Ames Research Center (ARC) in Palo Alto, California. Admiral Joseph Dyer opened the session by thanking the ARC staff for its assistance during the Panel's fact-finding sessions and for the opportunity to tour select ARC facilities. Both the Admiral and Mr. John Marshall observed that ARC personnel evince obvious pride in, and enthusiasm for, their work. Admiral Dyer commended ARC for the high level of professional, work-related morale throughout the facility and for an outstanding job of onsite historical preservation (as evidenced by the unaltered preservation of the former Moffett Naval Air Station Bachelor Officers' Quarters, now the Ames Lodge).

Mr. Marshall addressed ARC airfield operations, noting his concern from a safety perspective because of the small number of operations on a daily, weekly, and monthly basis. He emphasized that the ASAP did not review (or intend to perform) operation checks and that his comments should not be construed as criticism, but rather as an expression of concern about normal airfield, tower, and air traffic control (ATC) operations and airfield management proficiency—simply because of a lack of regular demand for services. He also declared that the ARC airfield facilities represent a wonderful resource that currently is not fully utilized.

OVERVIEW OF ARC FACILITIES

Admiral Dyer reviewed ARC facilities and operations based on a presentation by the ARC Deputy Director, Mr. Lewis Braxton, III. The Admiral reported that the Center has served NASA for seven decades since its founding in 1939, developing innovations that

cut across a wide breadth of technical fields, from lifting bodies to tiltrotor aircraft to science missions. For example, ARC personnel currently support the science associated with the Stratospheric Observatory for Infrared Astronomy (SOFIA), which is under the operational control of the Dryden Flight Research Center and the management direction of NASA Headquarters (HQ); the Kepler mission to search for habitable planets and life in the universe; high-speed supercomputing capabilities for multiple missions; and a number of Federal Aviation Administration (FAA) activities that encourage commercial aviation.

Admiral Dyer briefly summarized the ARC financial and personnel profile. With an annual budget of approximately $900 million, ARC employs about 1,250 civil servants and 1,300 contractors—a decline of slightly more than 50 percent since the early 1990s, when the integrated workforce totaled approximately 5,500.

The top five ARC priorities (and associated budget allocations) are (1) real prowess in supercomputing and information technology (IT) support for the entire NASA enterprise, basically the ARC center of gravity ($200 million); (2) aeronautics and aerospace infrastructure that is tied to geography (i.e., to proven existing facilities, activities, and personnel) and underpins NASA operations as well as some Department of Defense classified work ($100 million); (3) a heavy emphasis on science (e.g., astrobiology, Earth sciences, space biosciences) in support of NASA missions ($80 million to $100 million, much of it in grants); (4) support for small satellite start-up operations that focus on low-cost, entrepreneurial payloads ($60 million to $70 million); and (5) forward-leaning public-private cooperative ventures, most notably ARC's hosting of Google corporate aircraft ($10 million to $20 million).

Admiral Dyer noted that ARC confronts representative NASA workforce challenges, including the demographics of the workforce and the mean age of ARC civil servants (approaching 50). Thus, in roughly 5 years, the potential for a significant number of ARC civil servant retirements is a real concern, although perhaps somewhat less of an issue in the current financial environment. The ARC contractor workforce is significantly younger, with a mean age of approximately 30. The Admiral observed that ARC confronts a significant recruiting challenge because of the difficulty in finding affordable housing in the Silicon Valley area. General Bolden was impressed by the willingness of ARC executives and employees to live frugally so that they can continue to perform rewarding and important work at ARC, declaring that, at the end of the day, one cannot find better people doing more important tasks.

ARC SAFETY STATUS UPDATE

General Charles Bolden updated the status of ARC safety operations and identified three primary issues. First, as Mr. Marshall discussed previously, the Agency needs to review safety issues associated with decreased operations at the ARC airfield. Second, as NASA HQ is aware, ARC expends some $50 million a year on maintenance because of the age and condition of its facilities. General Bolden observed that ARC has played a critical role in several Shuttle missions over the last 2 years—and undoubtedly will fulfill a vital role in developing and flying Constellation and Orion—so additional attention to this

issue is warranted. Third, as Admiral Dyer previously documented, the ARC workforce (particularly the civil servant component) is aging.

General Bolden cited the presentation to the ASAP by Mr. David King, the ARC Associate Director for Safety, Environmental and Mission Assurance. The General was happy that ARC is emphasizing environmental issues (as reflected in Mr. King's title), not unlike industry in general today, where environmental issues frequently are incorporated into safety and quality groups. This emphasis is especially important when confronting the particular environmental challenges presented by California law.

General Bolden specified five positive developments at ARC. First, ARC makes exceptionally effective use of its metrics and operates a Web-based metrics database that all other NASA Centers can share, just by obtaining a password. In addition, after monitoring the operations of other centers, ARC adopted a contractor monthly accident report process to work more effectively with its contractors.

Second, ARC actively cultivates cross-cultural interactions with other NASA centers, including encouraging regular communications, looking for best practices at other centers that ARC can adopt, and openly sharing good ideas with other centers.

Third, ARC is very proud of its original Occupational Safety and Health Administration (OSHA) Voluntary Protection Program (VPP) Star certification in 2002 as well as its recertification in 2005 and its upcoming renewal in 2010. ARC personnel concluded that the turning point for VPP certification was holding supervisors accountable and assigning responsibility for safety to the lowest possible organizational level.

Fourth, ARC implemented the Ames Safety Accountability Program to generate a wide range of safety metrics that enable Center management to compare the performance of various directorates and to improve operations throughout the year. ARC also established the Ames Safety Awards Program, an event-oriented and activity-focused program that recognizes supervisors and employees for exceptional accomplishments in safety during the year. Although these two programs are not new or original, ARC has used them effectively to reduce accidents and enhance Center safety. For example, ARC is piggybacking its close call system by not only tracking close calls, but also proactively using that information as feedback to internal directorates that can take action to avoid such accidents.

Fifth, ARC is employing several new safety strategies. These include creating a number of internal control boards that report their insights directly to the Executive Safety Committee (ESC), chaired by the ARC Deputy Center Director. The ESC includes leaders from all 10 directorates and is facilitated by Mr. King. An example of one of these control boards is the ARC Electrical Review Team, established and specifically trained to assess electrical systems and high-voltage electrical safety facility-wide; identify unnecessary risks; and recommend risk mitigation options (e.g., training classes, safety manual revisions). The Electrical Review Team's thorough and rigorous activities helped ARC personnel to avoid electrical accidents by applying best practices (and in some cases exceeding OSHA regulations). As General Bolden noted, such approaches put safety first and foremost in the minds of leaders.

The ASAP encouraged Mr. King to continue emphasizing personal and organizational responsibility for safety, including conducting more frequent and routine briefings for the ARC Center Director on ESC and review group activities. Mr. Marshall agreed, but expanded the thought, noting that most NASA Centers have instituted executive committees that focus on safety and usually are chaired by the center deputy director. However, he suggested that the NASA Safety and Mission Assurance (S&MA) Office should study the need for a more formal requirement that each center director be briefed on all safety activities (e.g., by scheduling annual briefings on the status and progress of the safety program). Ms. Joyce McDevitt observed that such briefings should not stop at the center director level, but rather should extend to the NASA Administrator. Citing ARC as an example of the use of metrics to motivate each organizational element to achieve outstanding performance, she hypothesized that the same types of performance-driven pressure points could be created at higher management levels. Commenting that the ASAP has completed its most recent cycle of visits to all NASA Centers, Admiral Dyer asked the Panel members how they would evaluate the centers in terms of relative safety, focusing on process rather than ordinal ranking. He submitted that the Panel does not know the answer because each NASA Center exhibits tremendous local character in measuring performance and safety. He recalled that the Panel has found such diversity—and the consistent lack of NASA-wide standardization—frustrating in the past. In the opinion of the Panel, the reluctance of NASA HQ and S&MA to mandate some form of standardization makes it difficult at best to promote exemplary ideas and activities so that they gain the traction necessary to cross-pollinate successfully among the NASA Centers. Consequently, Admiral Dyer envisioned a multi-center safety briefing to the Administrator as comparable to touring many foreign lands and cultures. Dr. Jim Bagian broadened the issue to the perception gained by the Panel during its meetings that NASA leaders view standardization as stifling innovation. NASA HQ and S&MA should be more proactive in using effective safety tools and best practices from individual centers to establish a basic set of S&MA–related standards and processes that function as minimum requirements while still allowing centers to institute more restrictive, demanding standards and processes.

ARES I DEVELOPMENT STATUS

Dr. Bagian updated the status of Ares I development based on a teleconference presentation on thrust oscillation by Mr. Garry Lyles, Associate Director for Technical Management in the Marshall Space Flight Center (MSFC) Engineering Directorate. This thorough follow-up to a presentation at the ASAP third quarterly meeting at MSFC addressed concerns about, and strategies for, mitigating thrust oscillation problems.

Dr. Bagian summarized the first-stage thrust oscillation problem, which might create a maximum acceleration due to gravity (g) force or level of vibration that would make it physiologically difficult for astronauts to respond to instructions, monitor displays, or take needed actions—or, in the worst case, would affect their long-term health. Noting that slight variations in the baseline architecture could trigger crew health issues, he commended NASA for diligently reviewing this issue rather than simply resorting to a hastily developed design change.

Dr. Bagian addressed several risk mitigation options—at the top level (strictly external to Orion), in the Ares stack, or a combination of both—that NASA is addressing. He highlighted two plausible options that had been identified, interstage isolation with mass dampers and crew seat damper versus active mass damping at the interstage, which will not impact Orion payload or weight factors.

Dr. Bagian identified the missing information on crew performance as a critical determinant in selecting the appropriate risk mitigation option. He reported that ARC centrifuge testing is being completed, so results are not yet available, but informed the Panel that the current centrifuge test will not necessarily be adequate to support a decision on the likelihood of persistent acceleration and vibration effects on crew performance during second-stage operations because a parametric study was being conducted versus a simulation of the launch profile. Dr. Bagian proposed recommendation 2008-04-01.

Admiral Dyer confirmed that the Panel expressed some significant concerns about vibrations at the last quarterly meeting. He indicated that after considerable work, Panel members are considerably less anxious about vibration issues. Admiral Dyer agreed, concluding that although progress has been made, trade-offs must be made (in an already weight-constrained platform) based on a broader understanding of thrust oscillation and effects on the crew. He affirmed the need for additional study and ongoing ASAP monitoring.

OVERVIEW OF NEW HUMAN RATING STANDARD

Mr. Marshall addressed the new Human-Rating Requirements for Space Systems (NPR 8705.2B), issued in May 2008 and summarized in a presentation by Mr. Wilson Harkins, Director of the Mission Support Division of NASA HQ. Mr. Marshall noted that the ASAP has been interested in these requirements for some time, but additional dialogue and technical review are necessary for the Panel to understand the rationale for the new changes. He also emphasized the need to understand the history underlying the evolution of the human-rating requirements (HRR) system, which began at the Johnson Space Center (JSC) in 1991; this release is the fourth revision. He suggested that after 16 years, a review of the system history and evolution is probably very timely. This NASA Procedural Requirement does not represent a replacement of program management staff, just the definition and implementation of the standards required to protect astronauts.

Mr. Marshall cited the implication of the HRR for, and their application to, the Commercial Orbital Transportation Services (COTS) mission and NASA as one of the issues of concern to the ASAP. He reported that the HQ Office of S&MA has confirmed that the FAA holds responsibility for oversight of commercial activities in space, so the HRR will not normally apply to COTS vendors of space tourism. However, if a commercial firm is carrying NASA astronauts or other mission personnel, the HRR would apply, so COTS manufacturers have an incentive to participate in, and comply with, the HRR system (beyond protecting their own personnel). As Mr. Marshall explained, the HRR standards provide the maximum capability to safely recover crew members from hazardous situations, but they are not, and do not conflict with, other in-place reviews and procedures. The HRR standards do not apply to the Shuttle,

International Space Station (ISS), or Soyuz, which are mature programs in the latter stages of their lifetimes. However, the HRR will be available for, and applicable to, the Constellation Program. (In fact, as Mr. Marshall pointed out, the HRR revision process focused on Constellation and was heavily influenced by the members of the Constellation team, yet the change will be implemented NASA-wide.)

Mr. Marshall briefly described the six significant changes in the new HRR version. First, the certification official is now a body of people, specifically the NASA Associate Administrator (AA) supported by the AA for Space Operations, AA for Exploration Systems, technical authorities, and JSC Center Director. Second, the required Human-Rating Certification Package (HRCP) is now a series of discrete deliverables submitted at program milestones. Third, the HRR standards now apply to crewed test flights, which previously were not explicitly documented. Fourth, this HRR version implements changes to the technical mandatory standard citations, adding new documents and deleting those that no longer apply or have been superseded. Fifth, the failure tolerance standard changed from no two failures resulting in crew or passenger fatality of permanent disability to the current minimum of one failure tolerant to catastrophic events, with the specific level of failure tolerance derived from an integrated design and safety analysis. As Mr. Marshall observed, the ASAP spent quite a bit of time discussing what this change means, but still requires further definition and enhanced clarity. The new standard introduces tremendous flexibility in satisfying this requirement, so significant focus is necessary to understand its scope and implications. Sixth, the inadvertent actions standard shifted from no two inadvertent actions (during operation or in-flight maintenance)—or a combination of one inadvertent action and one system failure—resulting in crew or passenger fatality or permanent disability to the current standard of a minimum of one inadvertent operator action (as identified by the human error analysis) without causing a catastrophic event and tolerance of one inadvertent operator action in the presence of a single system failure. Mr. Marshall concluded that this change also requires further definition and dialogue.

Ms. McDevitt observed that the probability of loss of crew (LOC) or loss of mission (LOM) underlies the HRR, which means that objectives must be declared, consistent with other requirements that necessitate the conduct of probabilistic risk assessments (PRAs). On the basis of previous and current use of PRAs in NASA, she concurred with NASA that the best application is performing trade studies (usually at the subsystem or element level), that is, reviewing various options and making the best decision on the appropriate course of action. However, the HRR standard specifies an "integrated design and safety analysis." Ms. McDevitt said that comments from engineers at the NASA Centers indicated serious concern about whether PRA is sufficiently solid to use as a validation of compliance. She also expressed concern about the involvement and training of responsible personnel, who reside not only within the Agency, but also with the various contractors that develop elements and subsystems; these personnel must support the validation and verification of compliance to the numerical goals. Ms. McDevitt concluded that a considerable culture change will be required at NASA in implementing the new HRR; therefore, the Agency must devote its attention to delivering the necessary orientation and training so that all of the supporting organizations will consistently perform and apply the required integrated design and safety analysis.

Mr. Marshall expressed his concern that the results of PRA trade studies indicate that one option is better than another, but the "minimum" HRR standard demands that an option be as good as; without that, failure tolerance drops from two to one.

Admiral Dyer attempted to simplify the multivariate problem down to a two-level issue. The designer can incorporate a lot of weight and safety margin or less of both, but needs both a decision from management and good engineering practices (whatever that means in this context) to proceed. The ASAP therefore is concerned that the clarity of guidance required for design is not sufficiently transparent under the new HRR standard.

ARC CONSTELLATION PORTFOLIO

Ms. McDevitt reviewed ARC activities in support of the Constellation Program, noting examples of particular relevance to program safety and referencing a presentation by Dr. Carol Russo, ARC Deputy Director of Exploration Technology. First, she reported that ARC has assumed the lead role on development of the thermal protection system (TPS) for the Orion Crew Exploration Vehicle (CEV), a natural role given the Ames arcjet facility and ARC's considerable experience in TPS development for the Space Shuttle. Second, ARC is developing a single heat shield for CEVs returning from both lunar orbit and low-Earth orbit (LEO) and, at the preliminary design review, will deliver the heat shield design to the prime contractor for subsequent production.

Ms. McDevitt commented that testing the various LEO and lunar orbit return conditions (the latter flying 70 percent faster than a returning Shuttle) will require more sophisticated arcjet facilities than those currently available at ARC, which are scheduled for upgrading.

Ms. McDevitt noted that ARC is supporting Orion by developing aerodynamic and aerothermal databases; conducting high-fidelity modeling and simulations; and performing aerodynamic and aeroacoustic testing and analysis (including use of the ARC wind tunnels). She reported that the ARC modeling and simulation capabilities have improved significantly over the last decade as ARC has assembled supercomputing resources that nearly doubled from 2007 to 2008 and are expected to triple from 2008 to 2009 (based on the number of processors). ARC now operates the third most powerful supercomputer in the world, offering NASA a unique capability that is well suited to complex Constellation simulations.

Ms. McDevitt emphasized that ARC also is working on the Simulation-Assisted Risk Analysis (SARA) project, which uses probabilistic risk analysis (PRA) and multidisciplinary physics-based models to analyze the launch abort system, stage separation, and blast wave propagation. As Dr. Bagian mentioned, ARC also is conducting centrifugal research to support the Ares thrust oscillation study of the effects of vibration and acceleration on crew performance.

In addition, Ms. McDevitt highlighted ARC work on mission assurance systems for Constellation, applying the commercially available Bugzilla software to develop a centralized, NASA-wide, Web-based, open source system that offers integrated searching and linking capabilities with other Constellation S&MA database systems, such as the Problem Reporting and Corrective Action (PRACA) system, Hazard Analysis database, Failure Modes Effects Analysis and Critical Items List databases, and Government

Mandatory Inspection Point database. She concluded that ARC had achieved a huge success previously in developing a PRACA system that overlays existing database systems; both the Space Shuttle and ISS programs adopted this system.

ARC AERONAUTICS OPERATIONS

Admiral Dyer emphasized the value of this opportunity to closely observe ARC operations, including its very interesting and important work on air traffic management (ATM) and ATC. He observed that existing delays will be compounded by the projected doubling of air traffic in the coming decade, creating a serious need to manage higher-density air traffic in all areas, including terminals and the ever-increasing number of high-density airports throughout the nation. ARC is working in cooperation with the FAA and other NASA Centers to address and offload the human element, transferring the ATM and ATC burden to automated computer operations. The Admiral noted that ARC is reviewing new means of aircraft separation.

As a resident ASAP civil aviation expert, Mr. Marshall commented that ARC is clearly a component of a much larger picture, but a very important component. Aviation safety is confronting increasingly formidable ATM and ATC challenges as the number of aircraft grows, augmented by the introduction of very light jets in the next 10 years (which will add some 5,000 aircraft to the nation's skies) and the expansion of general aviation and commercial flights. In short, the air traffic system is saturated, and a new system of control is absolutely required to provide the necessary redundancy and safety while simultaneously addressing on-time performance. Mr. Marshall observed that ARC personnel are endeavoring to deconflict the passage of aircraft in limited and restricted airspace, and they earn very high marks for their contributions. In addition, ARC is supporting the FAA (the executive agency lead) and other Government agencies (e.g., the Department of Transportation, Department of Commerce, Department of Defense) to develop the Next-Generation Air Transportation System (NextGen).

General Bolden concurred, reporting that his opportunities to work with the FAA have confirmed that ARC work is particularly important in the development of NextGen and future aircraft. As new aircraft and systems emerge, ARC is cooperating with the FAA to maintain the nation's world-class air traffic system, and the General was impressed with ARC efforts.

General Bolden also described the ARC Vertical Motion Simulator (VMS), which he characterized as a national treasure, a one-of-a-kind simulator that can travel 60 feet vertically and 40 feet horizontally. The VMS system includes five interchangeable cabs that can be configured to simulate any aerospace vehicle (existing or planned). During its tour of the VMS, the ASAP observed a rudder loss test that ARC was conducting for the FAA.

ASAP RECOMMENDATIONS, FOURTH QUARTER, 2008

2008-04-01. The ASAP notes that there is not a consistent Agency-wide understanding of the technical concerns associated with thrust oscillation for the Ares vehicle, especially with respect to the impact on crew performance due to the immediate and residual effects of launch vibration and acceleration. The ASAP therefore recommends that NASA ensure that all concerns are appropriately evaluated and communicated to stakeholders and that a consensus exists on the rationale for the solutions ultimately adopted.

2008-04-02. The ASAP recommends that NASA obtain greater validation that the new Human-Rating Requirements Standard meets the safety requirements of a broad range of future human spaceflight programs by scheduling an external review by an independent "gray-beard" assessment panel.

2008-04-03. After the Human-Rating Requirements Standard is reviewed and validated, the ASAP recommends that NASA develop specific guidelines and tools, widely available training courses, and implementation evaluation criteria that enable system safety and reliability personnel to effectively define and apply the new integrated design and safety analysis approach specified by the standard.

2008-04-04. The ASAP recommends that NASA designate an office of prime responsibility that will serve as the champion of the Human-Rating Requirements Standard process to ensure that every program and relevant subject-matter expert uniformly, objectively, and aggressively implements the new NPR 8705.2B standard.

2008-04-05. The ASAP recommends that the Executive Safety Committee (ESC) at each NASA Center ensure that the Center Director is fully informed about ESC activities and conclusions.