

A photograph of the Space Shuttle Columbia in orbit above Earth. The shuttle is oriented vertically, with its nose pointing towards the top of the frame. The Earth's surface is visible in the background, showing a mix of blue oceans and white clouds. The shuttle's external tank and solid rocket boosters are clearly visible. The orbiter is attached to the external tank, and the payload bay is open, revealing various equipment and solar panels. The shuttle is illuminated by the sun, creating bright highlights and deep shadows. The overall scene is a dramatic view of human spaceflight.

AEROSPACE SAFETY ADVISORY PANEL

ANNUAL REPORT
FOR 2010

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

January 13, 2011

The Honorable Charles F. Bolden, Jr.
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Mr. Bolden:

Pursuant to Section 106(b) of the National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155), the Aerospace Safety Advisory Panel (ASAP) is pleased to submit the ASAP Annual Report for 2010 to the U.S. Congress and to the Administrator of the National Aeronautics and Space Administration (NASA). ASAP members believe that NASA will face challenges implementing the Nation's space program under the Administration's and Congress' new direction for the Agency.

This report is based on the Panel's 2010 quarterly fact-finding and public meetings; "insight" visits and meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members' expertise.

In Section II of this report, the Panel provides a summary of the safety-related issues that the Agency confronts at this time. First and foremost is our concern over the lack of clarity and constancy of purpose among NASA, Congress, and the White House, which we believe increases the likelihood that essential knowledge and competencies in the workforce (either contractor or Government) such as those involving important safety considerations, lessons learned, and past experience will not be present to effectively reduce risk going into the future. Other important safety issues relate to human spaceflight: the commercial human spaceflight acquisition strategy and safety approach; knowledge transfer; and how safe is "Safe Enough." During the year, the Panel also had recommendations on the Federal Aviation Administration (FAA)/NASA relationship, workforce and safety culture, infrastructure and facilities management, standardization of approaches, and astronaut health and longitudinal health study data. During the coming year, the Panel expects to continue its attention to these issues, as well as increase its focus on challenges facing the International Space Station.

The Panel hopes that our summary of safety-related issues will help focus attention on the important decisions and the direction of the Agency.

NASA's senior leaders and staff members offered significant cooperation to support the completion of this document. I therefore submit the ASAP Annual Report for 2010 with respect and appreciation.

Sincerely,



Joseph W. Dyer, VADM, USN (Ret.)
Chair
Aerospace Safety Advisory Panel

Enclosure

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

January 13, 2011

The Honorable Joseph R. Biden, Jr.
President of the Senate
Washington, DC 20510

Dear Mr. President:

Pursuant to Section 106(b) of the National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155), the Aerospace Safety Advisory Panel (ASAP) is pleased to submit the ASAP Annual Report for 2010 to the U.S. Congress and to the Administrator of the National Aeronautics and Space Administration (NASA). ASAP members believe that NASA will face challenges implementing the Nation's space program under the Administration's and Congress' new direction for the Agency.

This report is based on the Panel's 2010 quarterly fact-finding and public meetings; "insight" visits and meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members' expertise.

In Section II of this report, the Panel provides a summary of the safety-related issues that the Agency confronts at this time. First and foremost is our concern over the lack of clarity and constancy of purpose among NASA, Congress, and the White House, which we believe increases the likelihood that essential knowledge and competencies in the workforce (either contractor or Government) such as those involving important safety considerations, lessons learned, and past experience will not be present to effectively reduce risk going into the future. Other important safety issues relate to human spaceflight: the commercial human spaceflight acquisition strategy and safety approach; knowledge transfer; and how safe is "Safe Enough." During the year, the Panel also had recommendations on the Federal Aviation Administration (FAA)/NASA relationship, workforce and safety culture, infrastructure and facilities management, standardization of approaches, and astronaut health and longitudinal health study data. During the coming year, the Panel expects to continue its attention to these issues, as well as increase its focus on challenges facing the International Space Station.

The Panel hopes that our summary of safety-related issues will help focus attention on the important decisions and the direction of the Agency.

NASA's senior leaders and staff members offered significant cooperation to support the completion of this document. I therefore submit the ASAP Annual Report for 2010 with respect and appreciation.

Sincerely,



Joseph W. Dyer, VADM, USN (Ret.)
Chair
Aerospace Safety Advisory Panel

Enclosure

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

January 13, 2011

The Honorable John A. Boehner
Speaker of the House of Representatives
Washington, DC 20510

Dear Mr. Speaker:

Pursuant to Section 106(b) of the National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155), the Aerospace Safety Advisory Panel (ASAP) is pleased to submit the ASAP Annual Report for 2010 to the U.S. Congress and to the Administrator of the National Aeronautics and Space Administration (NASA). ASAP members believe that NASA will face challenges implementing the Nation's space program under the Administration's and Congress' new direction for the Agency.

This report is based on the Panel's 2010 quarterly fact-finding and public meetings; "insight" visits and meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members' expertise.

In Section II of this report, the Panel provides a summary of the safety-related issues that the Agency confronts at this time. First and foremost is our concern over the lack of clarity and constancy of purpose among NASA, Congress, and the White House, which we believe increases the likelihood that essential knowledge and competencies in the workforce (either contractor or Government) such as those involving important safety considerations, lessons learned, and past experience will not be present to effectively reduce risk going into the future. Other important safety issues relate to human spaceflight: the commercial human spaceflight acquisition strategy and safety approach; knowledge transfer; and how safe is "Safe Enough." During the year, the Panel also had recommendations on the Federal Aviation Administration (FAA)/NASA relationship, workforce and safety culture, infrastructure and facilities management, standardization of approaches, and astronaut health and longitudinal health study data. During the coming year, the Panel expects to continue its attention to these issues, as well as increase its focus on challenges facing the International Space Station.

The Panel hopes that our summary of safety-related issues will help focus attention on the important decisions and the direction of the Agency.

NASA's senior leaders and staff members offered significant cooperation to support the completion of this document. I therefore submit the ASAP Annual Report for 2010 with respect and appreciation.

Sincerely,



Joseph W. Dyer, VADM, USN (Ret.)
Chair
Aerospace Safety Advisory Panel

Enclosure



I. INTRODUCTORY REMARKS 1

A. The Aerospace Safety Advisory Panel (ASAP) 1

B. ASAP Observations About NASA Accomplishments in 2010 1

 1. Three Successful Space Shuttle Launches 1

 2. Ten Years’ Continuous Human Occupation Aboard the International Space Station (ISS) . . . 1

 3. Management Efforts to Ease Workforce Transition 2

 4. Safety and Mission Assurance (S&MA) Technical Excellence Program (STEP) 2

 5. NASA Responses to ASAP Recommendations 2

 6. NASA Assistance with the Chilean Miners’ Rescue 2

II. ISSUES AND CONCERNS 3

A. Clarity and Constancy of Purpose 3

B. Human Spaceflight Acquisition Strategy and Safety Approach 4

C. Knowledge Transfer 6

D. How Safe Is Safe Enough? 7

E. FAA/NASA Relationship 8

F. Workforce and Safety Culture 9

G. Infrastructure—Facilities and Facilities Management 10

H. Standardization of Approaches 11

I. Astronaut Health and Longitudinal Health Study Data 12

J. International Space Station Challenges 12

K. Russian Dependence 13

III. CONCLUSION 14

APPENDIX: Summary and Status of ASAP 2010 Recommendations 17

CD TABLE OF CONTENTS

- Attachment 1: Charter of the Aerospace Safety Advisory Panel
- Attachment 2: ASAP 2010 Recommendations, NASA Responses, and Status
- Attachment 3: ASAP 2010 Quarterly Meeting Minutes
- Attachment 4: 2010 Activities of the Aerospace Safety Advisory Panel
- Attachment 5: Aerospace Safety Advisory Panel Members and Staff



I. INTRODUCTORY REMARKS

A. The Aerospace Safety Advisory Panel (ASAP)

The ASAP was established by Congress in 1968 to provide advice and make recommendations to the NASA Administrator on safety matters.¹ The Panel holds quarterly fact-finding and public meetings and makes one or more “insight” visits per year to NASA Field Centers or other related sites. It reviews safety studies and operations plans and advises the NASA Administrator and Congress on hazards related to proposed or existing facilities and operations, safety standards and reporting, and NASA management and culture related to safety. Although the Panel may perform other duties and tasks as requested by either the NASA Administrator or Congress, the ASAP members normally do not engage in specialized studies or detailed technical analyses.

This report highlights the issues and concerns that were identified or raised by the Panel during its activities over the past year. The Panel recommendations submitted to the Administrator during 2010 are summarized in the Appendix at the end of this report.² They are based upon the ASAP quarterly fact-finding meetings and public meetings; “insight” visits and meetings; direct observations of NASA operations and decision-making; discussions with NASA management, employees, and contractors; and the Panel members’ expertise.

B. ASAP Observations About NASA Accomplishments in 2010

(1) Three Successful Space Shuttle Launches

NASA safely launched Shuttle Endeavour (STS-130) on February 8, 2010; Shuttle Discovery (STS-131) on April 5, 2010; and Shuttle Atlantis (STS-132) on May 14, 2010. All flights carried equipment and cargo to the International Space Station (ISS). The workforce stayed focused on the tasks at hand and demonstrated noteworthy efforts to maintain rigor and attention to detail. The ASAP was pleased to see that safety continues to be NASA’s number one core value.³

(2) Ten Years’ Continuous Human Occupation Aboard the International Space Station (ISS)

On its 10-year anniversary on November 2, 2010, the ISS, an amazing engineering feat, had been safely operated through 196 people visiting, 34 Shuttle visits, 40 Progress visits, 24 Soyuz visits, one Automated Transfer Vehicle (ATV) visit, and one H-II Transfer Vehicle (HTV) visit, while travelling a total distance of 1.5 billion miles without major mishap. It is humankind’s longest continuously inhabited spacecraft, and if funding is made available, its service life is anticipated to be extended to 2020.

1. The ASAP Charter is included as Attachment 1 on the enclosed CD.

2. The full text of all the 2010 recommendations is included as Attachment 2 on the enclosed CD.

3. As stated in NASA Policy Directive (NPD) 1000.0A, dated 8/13/2008.



(3) Management Efforts to Ease Workforce Transition

The Shuttle to Constellation workforce transition was identified as a critical issue in the ASAP's 2009 Annual Report. During 2010, the Panel visited the NASA Field Centers that are most involved with workforce transition issues, including the Kennedy Space Center (KSC) at Cape Canaveral, Florida; the Johnson Space Center (JSC) in Houston, Texas; and the Marshall Space Flight Center (MSFC) in Huntsville, Alabama. KSC has established workforce transition offices that do counseling; provided training on Federal and private-sector résumés, applications, and interviewing; and held job fairs. At JSC, the partnership between civil servants and contractors is unprecedented, and processes are in place to facilitate and assist in every way. MSFC has undertaken aggressive communications outreach from the Center Director's office. The Panel is pleased with the overall results achieved thus far during this difficult time to ease workforce transition to other projects within NASA or outside the Agency.

(4) Safety and Mission Assurance (S&MA) Technical Excellence Program (STEP)

NASA has an excellent process—called STEP—to improve the knowledge base and professionalism of the S&MA workforce. The ASAP was impressed with the program that went from concept to actual practice to having over 700 graduates in STEP level 1 in one year. In March 2010, the NASA Safety Center (NSC) received approval to proceed with the execution of the elements in levels 2 through 4, which currently is under way. The ASAP was very pleased with the STEP level 1 accomplishment and applauds NSC's plans moving forward.

(5) NASA Responses to ASAP Recommendations

During 2010, the ASAP received responses to 41 outstanding recommendations: 8 from 2008, 23 from 2009, and 10 from 2010. A total of 27 recommendations were closed by the ASAP. We appreciate senior management's personal involvement to significantly reduce the backlog of unanswered recommendations. Currently, there are 30 open recommendations—for 21 of which the ASAP has received an initial reply but has requested that the recommendation remain open for additional information, action, or verification of implementation. Eight of the unanswered recommendations are from the latter two quarterly meetings. NASA leadership is to be commended for its timely response and attention to these issues.

(6) NASA Assistance with the Chilean Miners' Rescue

The Chilean government and people are to be praised for their unwavering commitment, steadfast determination, and resounding success in safely rescuing all 33 miners trapped underground for many weeks. A NASA team traveled to Chile in the early days of the miners' crisis to bring the knowledge and experience of spaceflight to assist in the rescue endeavor. NASA's expertise in maintaining its astronauts' physiological and psychological health in space's hostile environment, as well as the Agency's technical and engineering expertise in spacecraft design, proved valuable in a situation that was out of NASA's ordinary line of work.



II. ISSUES AND CONCERNS

A. Clarity and Constancy of Purpose

Clarity and constancy of purpose among NASA, Congress, and the White House are the ASAP's overarching concerns.

While we are seeing the end of the Space Shuttle Program and the proposed termination of the Constellation Program and its budget authorization, we have yet to see any clear articulation or funding for a new plan. In this discussion, the ASAP makes a basic assumption that the United States desires to retain a human spaceflight and exploration program, although the precise form and extent have yet to be defined.

For a considerable period, the need for clarity and constancy of purpose has been a key ASAP message. Today the issue is still present and becoming ever more pressing. What is NASA's exploration mission? The debate's concentration on the ability of commercial providers to offer transportation to Low Earth Orbit (LEO) has overshadowed the much larger debate about exploration beyond LEO. What should our next destination goal be? An asteroid? The Moon? Mars? The decision affects the necessary technology programs needed to prepare for such a mission. More importantly, from the aspect of safety, the lack of a defined mission can negatively affect workforce morale and the ability to attract and maintain the necessary skill sets needed for this high-technology venture. The lack of clarity and constancy of purpose increases the likelihood that essential knowledge and competencies in the workforce (either contractor or Government), such as those involving important safety considerations, lessons learned, and past experience, will not be present to effectively reduce risk going into the future.

Even for commercial transportation to LEO, we find uncertainty. What is to be the acquisition strategy to integrate commercial programs to support NASA's LEO mission? What is to be the system of oversight that protects both NASA astronaut safety and general public safety, given a system of commercial providers? If something goes wrong, who would be liable? When one considers assigning Government "employees" (i.e., astronauts) to a commercial vehicle, what are the criteria for validating their safety, what is the process for determining that the criteria have been met, and how do we know that initial safety precautions/designs have been maintained? In effect, how safe is safe enough for either exploration or sustainment missions? Clearly, uncertainty is driving the safety risk factor to a higher level, as it does in any endeavor. Space travel's significant challenges merely heighten the exposure and the consequences.

NASA's stated goals from 2008 to 2010 have changed dramatically. The Moon and Mars sequential exploration objectives were substantially changed or discarded, and associated hardware development such as the Constellation Program was proposed for cancellation. These changes, together with others such as questions regarding the use of Orion, are examples of how uncertainty has become a critical issue.



A key point has been made by each Center that the ASAP has visited over this past year—the lack of guidance, clarity, and mission has increased the potential for risk, negative consequences to the workforce, and additional expense resulting from duplicative efforts or efforts that are ultimately determined to be unnecessary due to a change of course.

In the ASAP's view, it is not in the Nation's best interest to continue functioning in this manner. The Congress, the White House, and NASA must quickly reach a consensus position on the future of the Agency and the future of the United States in space. The discussion must move beyond LEO and on to the necessary steps needed to achieve our future in space, whatever that might be. The constancy of purpose drives workforce loyalty and high achievement and attracts high levels of expertise that clearly make for a safer and lower-risk solution.

The ASAP recognizes that this is a fundamental problem that NASA alone cannot solve. It goes beyond the Agency—and clearly is on the shoulders of the Administration and Congress, and that is where it ultimately must be addressed.

B. Human Spaceflight Acquisition Strategy and Safety Approach

The ASAP has never taken a position on whether space transportation involving NASA astronauts should be an internally developed program or a commercial program; however, the Panel has stated that its position and intent is that NASA achieve well-defined programs that can be completed safely, can be executed efficiently, and are in the Nation's best interest, in whatever direction the Administration and Congress choose to go forward.

Understanding the human spaceflight acquisition strategy going forward is a challenge that the ASAP discussed this year.

Acquisition Strategy—What Does It Mean?

“Acquisition strategy” includes a myriad of things—an understanding of what is being procured for what purpose, what type of contract will be used, how competition will be interjected, how oversight and insight will be part of the plan, how the product/services will be certified, and how the bona fides of any agreement will be met.

Acquisition strategy is a central column in the Government's program initiation decision, the foundation for the request for proposal provided to industry, and the place where the Agency identifies the risks being accepted. Government procurement contracting officers are required to select a contract type that is consistent with the level of program risk. The alternatives may include fixed-price, including fixed-price-incentive, or cost-reimbursable-type contracts.

Is Acquisition Strategy Linked to Safety?

Acquisition strategy is PROFOUNDLY linked to safety. The principles of design and system robustness, as well as the delicate trades among cost, schedule, performance, and safety, are communicated to the supplier via the request for proposal that is derived from the acquisition strategy. Acquisition strategy articulates the design goals and optimizes placement on a continuum between “cheapest



achievable” and “best possible.” Additionally, the strategy lays out the success criteria and reward structure. The safety linkage is intimate and inseparable.

Financial Risk from the Supplier’s Perspective

In our economic system, publicly traded corporations are properly charged with acting in their investors’ best interests. Corporate boards are required to align to this interest in carrying out their governance responsibilities. This alignment requires risk-and-reward assessment. The risk to corporations and investors is higher when producing under a fixed-price-type contract. However, so are the potential rewards that can be garnered during development or potential follow-on procurement. Fixed-price-type contracts are appropriate when a program is not overly complex or technically challenging. When there are significant complexities and risks (e.g., technical, cost, schedule, or safety), cost-reimbursable-type contracts are generally considered to be more appropriate and carry lower fiduciary risk to the corporation.

Financial Risk from the Government’s Perspective

The ASAP members have long and extensive experience with major procurements that are complex, risky, and similar to NASA’s Commercial Space Transportation Program. It is the Panel’s opinion that the ultimate financial risk to the Government is comparable when appropriately utilizing a cost-reimbursable-type contract or when inappropriately utilizing a fixed-price contract. In the inappropriate fixed-price arena, contract changes, renegotiations, and redirection yield “fixed-price” increases. Almost invariably in high-risk, fixed-price contracts, mistakes are made on both the Government and the commercial sides. In cost-reimbursable-type contracts, the Government agrees up front to fund the risk and uncertainties (though they may be bounded and the burden may be shared).

Contract Type and Safety Environment

Safety can suffer in high-risk, complex programs—or programs with new or unproven technology—when operating in a fixed-price environment. The Government (at least at first) demands delivery at the agreed-to price. The contractor responds with belt-tightening and cost-cutting. Too often, employees are pressured to provide less—less time, less quality, and less safety. The U.S. Navy’s multi-billion-dollar A-12 aircraft program, which remains in litigation after almost 20 years, is a classic case study in complex, high-risk, fixed-priced development contracts.

The ASAP is not yet comfortable with the harmony between technical readiness and the anticipated fixed-price contracting approach for NASA’s Commercial Space Transportation Program. A lack of compatibility between these elements can often increase risk as funding runs short and time runs out.

Urgent Need to Promulgate Acquisition Strategy

An acquisition strategy is fundamental to the development of standards and requirements for commercial crew transportation. The Panel has emphasized the necessity of developing and promulgating a good acquisition strategy as quickly as possible.



The Human Rating Requirements (HRR)—Another NASA “Commercial Space” Challenge Related to Acquisition Strategy and Safety

Human-rating a spacecraft is not a feature one can just simply add on once the vehicle is designed. It is a process that requires endurance and attention to detail to ensure that safety is driven into every aspect of the vehicle design and operations from the beginning in order to manage risk to an acceptable predefined level. Optimal safety and reliability are strategically and systematically incorporated into the vehicle from day one, concurrent with critical trade decisions considering vehicle mass and cost.

One of the key questions is the appropriate level of insight and oversight in any resulting agreement for commercial crew transportation services. If the acquisition strategy is for NASA (which holds fundamental knowledge about human spaceflight in the U.S.) to be “hands-off,” then there is risk that the needed knowledge is not transferred. Also, if NASA is hands-off but is going to make the determination on whether or not the system is sufficiently safe after it is designed and built, it would be a good thing if NASA communicated to the contractor whether or not the design is progressing successfully before the contractor spends billions of dollars. Somewhere between “hands-off” and “overbearing Government involvement” in commercial enterprise that drives up overhead and other costs, there is an optimal balance point. NASA is making progress at figuring out where that is, but it is an impressive challenge and one that will continue and requires further development.

C. Knowledge Transfer

Although the fiscal year (FY) 2011 President’s Budget Request effectively cancels the Constellation Program, there is a wealth of knowledge and lessons learned during the program’s design, development, and test activities. At some point in the future, this knowledge may become essential and, at a minimum, could well serve the next generation of rocket designers. Much of Constellation’s knowledge and lessons learned can be applied to future spaceflight vehicle and rocket developments, whether they are commercial or not.

The ASAP has recommended that NASA begin to document the tacit knowledge and to index and to organize the already documented explicit knowledge that has been learned and developed to date. NASA has identified several near-term preparatory activities associated with the Constellation Program, which should move forward as expeditiously as possible. The valuable knowledge and lessons learned from the Constellation Program must be captured quickly and in a format that enables records storage for long-term retrievability. The format needs to be easily accessible and searchable by a wide audience both inside and outside the Agency.

NASA has deep knowledge built over many years on how to put humans into space, and this knowledge could be very useful to commercial developers. There is excellent work being done across the spectrum of the Shuttle, the ISS, and Constellation. It will be a great loss to the Nation and to humankind if this knowledge is not captured, managed, and effectively utilized.



Knowledge capture should include not only technical lessons learned and traditional program information, but also broader perspectives such as program/project management; systems engineering; systems technology; critical processes; and functional support activities such as safety and mission assurance, technical authority, information systems, and human capital.

D. How Safe Is Safe Enough?

For the follow-on systems that will replace the Space Shuttle, the ASAP has long been asking the two interrelated questions, how safe is safe enough for human spaceflight? and how should that requirement be communicated to the designers and builders?

The ASAP applauds an overall review undertaken by NASA this year to establish a set of safety risk tolerances for human spaceflight. The acceptable mission risk for Loss of Crew (LOC) is now to be expressed in terms of three levels: (1) the Agency acquisition threshold, which is the highest risk level to be tolerated by the Agency—breaching this level would normally result in program cancellation; (2) the Program Design/Mission Requirement risk level, which is the “build to” level and is somewhat more conservative than the Agency threshold to allow a margin or buffer; and (3) a long-term maturity goal, which includes continuous-improvement upgrades and represents the long-term mission goal. This multitiered approach has merit and reflects the fact that probabilistic safety criteria are not a binary decision gate of “Safe” or “Unsafe” and that knowledge and experience are functions of time and should grow with the system’s utilization.

Unfortunately, in the Panel’s view, the numerical criteria chosen for these three levels may not be as safe as modern technology can and should provide. The “Agency acquisition threshold” for probability for LOC for each 210-day mission to the ISS is 1/150. The Program’s objective, or “build to” level, was chosen to be 1/270 for that mission. The long-term maturity goal is 1/750. The Panel notes that these analytical LOC criteria are an improvement relative to the Shuttle but are less improvement than expected given the Shuttle’s complex multimission nature, its lack of an abort system, its 30-year-old design, and the major technology advancements that have occurred since that design. These low numerical criteria are particularly worrisome since they only reflect the theoretical safety as determined by analyses. This type of analysis by its very nature cannot reflect the unknown hazards that historically have comprised the majority of the risks to human spaceflight. In order to allow for such unknown-unknowns, significant “margin” or “robustness” must be designed into a system. Confining our goals to small increments above the current system seems too limiting if we are to build systems to carry us forward for perhaps another 30 years.

The Panel recommended that NASA undertake an effort to reevaluate the LOC risk criteria to determine if they represent the best safety levels that can reasonably be provided by future safety-optimized human spacecraft. The process should involve stakeholders and the technical community and should consider technical feasibility as well as mission tradeoffs that might be required. NASA should determine what the current acquisition threshold, design “build to” requirement, and long-term goal numbers should be for the next refinement of safety risk tolerances. In addition, the next refinement should address how to select these levels such that they (1) encourage and incentivize continuous improvement



and (2) have a formalized and documented rationale for the levels selected and a process by which they can determine which improvements in the future should be undertaken. These rationales need to be clearly and explicitly communicated to all stakeholder groups in terms that not only are accurate, but can be contextually understood in relation to other risks that have been accepted in the past or that provide relevant understandable comparisons.

E. FAA/NASA Relationship

The President's FY 2011 Budget Request contains the following direction: "The budget funds NASA to contract with industry to provide astronaut transportation to the International Space Station as soon as possible, reducing the risk of relying solely on foreign crew transport for years to come. A strengthened U.S. commercial space industry will bring needed competition, act as a catalyst for the development of other new businesses capitalizing on the affordable access to space, help create thousands of new jobs, and help reduce the cost of human access to space."

Although there are many implementation details yet to be defined, the Administration's clear desire to develop a commercial crew capability has significant implications for how NASA's human space-flight program will operate in future years. Under current law, if a company is tasked with carrying out a launch, even if that launch is being conducted for the Government, the launch must be licensed by the FAA in order to ensure public safety. To ensure the safety of NASA employees and equipment aboard these launches, NASA must establish its own requirements, determine whether they have been met, and approve each launch. To ensure that NASA's safety and mission requirements are satisfied, it will be very important for NASA and the FAA to work together closely in providing Government oversight for these operations. This new partnership must be broad enough to consider the safety not only of those on the ground, but also those in the spacecraft and even the payload aboard the spacecraft. Such a process has to envelop the vehicles' design, maintenance, and operation; the launch/escape systems; and the ground infrastructure. Oversight is not an event; it is a process that continues as long as the system remains in service.

The potential benefits from a strong interagency partnership are evident. NASA has been launching humans into space for almost 50 years. At the same time, the FAA has more than 25 years of experience in regulating commercial space launches and 84 years (with its predecessor organizations) in regulating commercial air travel. The challenge will be for NASA and the FAA to avoid levying conflicting and/or unnecessarily burdensome requirements on the launch operators while still ensuring safe operations.

The Panel believes that it will be very important for NASA and the FAA to "practice" their new relationship during cargo-delivery and vehicle-development missions over the next several years. For example, it has already been decided that Commercial Orbital Transportation Services (COTS) and Commercial Resupply Services (CRS) missions will involve FAA licensing. Advantages of this approach include the capability to use existing processes for insurance, cross-waivers, Government indemnification for third-party excess claims, and the FAA's ability to take enforcement actions, if necessary, to ensure compliance with safety-related regulations. Continuing this same philosophy



during the Commercial Crew Development demonstration missions, prior to the flights that are scheduled to carry NASA astronauts, would offer additional opportunities to ensure that the appropriate safety measures were being incorporated in the operations.

F. Workforce and Safety Culture

The Agency has worked hard to maintain its reputation as a good place to work, especially as its mission changes. NASA has also been recognized as one of the better agencies in which to work within the Federal Government, and the staff members are to be commended for their efforts in this area.

The ASAP has followed the workforce continuity issue for a number of years. NASA had a good plan in place to transition the workforce (civil service and contractor) from Shuttle to Constellation and has been executing against that plan. With the recent changes in Agency direction, there is uncertainty within the workforce and a potential for lack of focus. It is natural for people who have no designated “landing spot” to spend their concentration on establishing their future as opposed to the task at hand. The fact that this has not become widespread nor has it yet resulted in a significant safety breach is a testament to the excellence of the current Shuttle workforce. Unfortunately, the probability of losing this workforce and its years of embedded knowledge must be recognized for the risk it carries to the next-generation systems. This lack of clarity and constancy of purpose noted earlier in this report has a direct and negative effect on workforce morale, attention to detail, and safety performance. Defined programs, either in the commercial industry or in the Agency, result in knowledgeable workers finding a place within the space environment. Absent such a program or programs, the best workers will find new roles outside the industry, and their knowledge and experience will be lost.

With the new FY 2011 budget, NASA’s work in human spaceflight will be changing. Safety and Mission Assurance (S&MA) work will also change, and new skills (or a different mix of skills) will be needed. As the new NASA direction becomes clearer, the S&MA organization should identify the skills, technologies, knowledge, and experiences that will be required of the future S&MA professional. NASA’s Office of Safety and Mission Assurance (OSMA) has established a team to evaluate current capabilities, perform trade studies and gap analyses, and develop recommendations. OSMA also intends to take an active role, working with each Center’s S&MA organization, to define the new safety and mission assurance roles to support the programmatic changes. The ASAP looks forward to reports on this subject in the coming year.

Cultural climate was often addressed and highlighted as an important issue in the Columbia Accident Investigation Board (CAIB) Report. During the Return-To-Flight timeframe, NASA conducted an examination of its safety culture; however, this activity lost scrutiny after a couple of years. In 2009, it was regenerated as a continuing program. NASA is off to a good start in this endeavor. A survey questionnaire has been developed, and Field Centers are responding. Data analysis is in process, as is the evaluation concerning the new questionnaire’s utility. With this new initiative, NASA should be able to address the question, what is the culture climate and how do you know? It is very important that this work be continued because the real learning in culture work comes with assessing



the changes over time. NASA needs to know where more emphasis or intervention is needed, and the Agency leadership needs feedback on how its behaviors can positively affect mission success.

G. Infrastructure—Facilities and Facilities Management

NASA facilities and aging infrastructure constituted an issue that was identified in last year's Annual Report. The ASAP continued to discuss this topic with NASA Headquarters senior management as well as senior management at the Field Centers that were visited over the past year.

The ASAP has identified several areas of concern from a safety perspective that are impacted by deteriorating infrastructure, whether they are labs, test facilities, or assembly areas. For infrastructure development, NASA had developed a beginning strategy, but while the details of this approach are still just emerging, the ASAP believes thus far this approach appears to be overly optimistic, requiring improbable amounts of infrastructure funding from Congress.

The ASAP has asked NASA to continue to identify safety-specific issues related to facilities maintenance and infrastructure improvement and to give the Panel periodic updates on how NASA plans to fund and resolve the issues. Thus far, NASA continues to struggle concerning this request because it does not track critical infrastructure safety issues Agency-wide.

The ongoing problem is lack of visibility into the size and scope of the deficiencies so as to identify the amount of funding necessary to deal with safety-critical infrastructure maintenance issues. Another challenge is how to maintain structures beyond their design life. Thus far, NASA appears to be more in a reactive mode than a corrective mode, intending to demolish facilities rather than repair them. Due to fiscal constraints, the ASAP believes there is a limit to NASA's ability to pursue the overall facilities plan in a satisfactory manner.

It has not been made clear to the ASAP what safety-risk criteria are used for the disbursement of capital improvement funds or what part of NASA's facilities budget for maintenance and repair is related to safety.

Although the Field Centers appear to be doing a good job in identifying facilities that have deficiencies that could pose a safety risk to employees or missions, the Agency still has not presented a systematic approach to prioritizing facilities and laboratories requiring safety-related repairs and harmonizing funding across the Agency to facilitate those repairs in the most effective manner.

In response to its questions, the ASAP has received a draft memorandum from NASA Headquarters that gives a summary of the overall unfunded maintenance status. All unfunded maintenance has an impact, but much of it does not impact safety. Unfortunately, the bottom line with respect to the question that was asked about the size of the safety portion of that backlog is stated in the memorandum: "NASA does not track funding for specific safety critical projects separately from the backlog." Another piece that is missing is a Headquarters overview of which Centers need the most help and how bad the overall situation is. In addition to providing supporting rationales for funding requests, this overview would help spot broad trends that might lead to economies of scale or identification of root causes.



The ASAP continues to wait for NASA Headquarters to provide the Panel with a methodology that would be used to identify the most safety-critical areas in the Agency and track the funding, as well as a plan that would minimize risk.

H. Standardization of Approaches

Mishap Investigation and Follow-Up

The ASAP has been following the process and the metrics that the Centers use to learn from mishaps that have occurred over the years. The Panel has seen considerable improvement in getting the initial announcements out much earlier in the process. However, at this point in time, there is not a well-established process for ensuring that the organization has learned from the outstanding items. For close calls, there is no clear or standardized prioritization technique. Mishap investigation and subsequent follow-up require a leadership effort. Ten relatively independent Centers make this challenge harder. There should be a work process whereby other Centers quickly receive information so that they can analyze it and see how it would apply to them. The NASA Administrator has recognized this problem, and progress is being made to correct it. The ASAP will continue to follow this issue.

Workforce Wellness

Over several mishap reporting reviews, the Panel has seen a preponderance of ergonomic-related injuries. A number of steps are being taken to improve ergonomic and human factors. Another effective countermeasure is workforce wellness. There are opportunities for encouraging workers to participate in a wellness program that includes an exercise regimen. Many organizations have demonstrated that wellness programs that provide the opportunity for workers to exercise during the workday reap an overall benefit both for the organization and for the individual worker. NASA should identify the alternatives that are available within the legal and personnel system and examine the most effective approach to encouraging a regular exercise regimen among the workforce.

Alcohol Use and Testing Policy

An Office of Inspector General (OIG) audit team reviewed NASA's actions to implement recommendations from three reviews (two internal and one external) relating to astronaut medical health and issued its report on July 6, 2010. The audit team found that NASA had not addressed the recommendation on alcohol testing but noted that NASA was already working on an employee alcohol testing policy in response to an ASAP recommendation in 2006 called "Random Drug and Alcohol Testing." The audit team felt that this policy would satisfy the intent once completed. While NASA has reported to the ASAP several completed actions that strengthen its policy on illegal drug use for employees and contractors, the one area reported as still open concerns developing the alcohol use and testing policy. Without an alcohol use and testing policy, safety- and flight-critical systems could be at risk, as well as workforce safety in general. The ASAP is concerned that NASA has failed to implement the alcohol policy for over three years. While it is encouraging that the OIG feels that the alcohol policy, when implemented, will satisfy the identified need, intention is no substitute for actual implementation, especially in view of the repeated failure to execute up to this point. The



ASAP has not received a formal status report in recent months and will be following up on this early in 2011 to determine when NASA will complete this task.

I. Astronaut Health and Longitudinal Health Study Data

Major changes have taken place at NASA's Johnson Space Center (JSC) regarding organization and business practices associated with space medicine. JSC has updated and modernized how NASA is handling the medical care of astronauts. It has established a Quality Assurance committee to guide actions and efforts that are necessary and has established safety and quality metrics that are being reported to NASA Headquarters. JSC has fully integrated all the work locations (e.g., Russia, White Sands, and KSC) with respect to the application of common electronic medical records. It has also done a financial and legal overhaul and review, and it now has the appropriate authority to implement medical care processes as common business practices. Much good work has been done, and more is ongoing.

Even though substantial research has been and is being done on the long-term effects of spaceflight on astronaut health, the various medically related hazards are still not fully understood and present concerns with respect to long-duration operations as well as crew health. The NASA Medical Operations group informed the ASAP that other Federal agencies such as the Department of Energy and Department of Defense have legislative authorization in place that allows them to more thoroughly monitor longitudinal health effects as well as to enable treatment for adverse health effects that are manifested long after exposure to a work-related hazard and that occur after separation from active service. Without such authority, NASA is restricted in its ability to identify operationally significant crew health hazards and properly plan appropriate countermeasures. The Agency needs a more reliable and robust mechanism to perform long-term surveillance on astronauts. NASA should actively explore avenues such as securing similar authority to that identified at other agencies that will allow it to more comprehensively identify medically significant spaceflight-related health hazards.

J. International Space Station Challenges

With passage of the NASA Authorization Bill, the life of the ISS can be extended to at least 2020. As the ISS enters its second decade, the lessons learned there will carry human exploration to Mars and beyond. With this opportunity come many challenges:

- *Logistics support*—April 2011 will be the last planned Shuttle mission (STS-134) to the ISS, although the Agency is requesting approval and funding for an additional logistics mission utilizing the launch-on-need vehicle (STS-335 reconfigured as STS-135) in the June 2011 time-frame. This will be the last U.S. logistics mission until commercial cargo services are available. As a result, NASA must rely upon a combination of ISS visiting vehicles from the International Partners—Russia, the European Space Agency (ESA), and Japan. Cargo upmass and volume capacity will be much more limited than with the Shuttle.
- *Crew transport*—Until commercial crew services are available, NASA must rely solely upon the Russian Soyuz vehicles to transport crew to and from the ISS.



- *Operational anomalies and extravehicular activities (EVAs)*—During ISS operations over the next 10 years, the nature of the safety risks is expected to change as a result of failures resulting from extended equipment usage in a very extreme environment; hazards associated with unplanned repair, disconnect, and replacement procedures; and longer exposure of the astronauts to space, and as a result of the “new” environment created by the termination of the Shuttle. A glimpse of the technical challenges ahead can be seen in this year’s failure and replacement of the ammonia pump—a significant failure in terms of the systems and humans on board, but one for which NASA fortunately had planned and provided a spare. Even the nature of this known risk has increased considerably, given that the pump has not yet been returned to Earth for in-depth troubleshooting and analysis. There are currently three spare pump modules on board ISS.
- *Increasing MicroMeteoroid and Orbital Debris (MMOD) risks*—The biggest safety threat to the crew on the ISS is MMOD, and that environment gets worse year by year. NASA needs to continue to closely watch this situation over the remaining ISS life.
- *Deorbit issues*—NASA needs a strong, comprehensive plan for emergency as well as planned deorbit of the ISS. At its last 2010 quarterly meeting, the ASAP reviewed end-of-life (EOL) plans for the ISS. However, the Panel would like to see more done on options that address potential emergency evacuation/loss of control scenarios. Also, NASA planning had assumed a Crew Exploration Vehicle (CEV) to perform the deorbit burn. With uncertainties surrounding the schedule on that type of vehicle, NASA has been looking at other options, including the ATV in combination with the Progress vehicle, as well as a single, modified Progress vehicle, which would offer the most capability. NASA needs to move forward to determine the best option for performing the deorbit and to plan now for its implementation.

The ASAP plans to increase its focus on the ISS topic in the coming year and will be examining the challenges the ISS will face in the coming decade.

K. Russian Dependence

After the last Shuttle flight, the U.S. and its ISS partners will be dependent on Russian, European, or Japanese vehicles for logistics resupply of the ISS until a commercial resupply capability becomes operational. Information to date shows progress on the U.S. commercial space effort; however, it remains approximately one year behind its original schedule. The U.S. and all other ISS participants will also be solely dependent on Russian Soyuz vehicles for crew transport to and from the ISS until a commercial space transportation services provider becomes operational. While this does not immediately translate into a safety issue, anytime one depends on a single-source solution, one runs the added risk of interruption in service due to some unforeseen contingency affecting that source. We have no evidence that Progress and Soyuz will be anything but as reliable as they have been; however, risk rises as the simple offshoot of dependence on a single-source provider.

Another potential utilization of the Russian capability could arise if it were required to perform an emergency evacuation or deorbit of the ISS. During the latter part of 2010, the ASAP began looking more closely at contingency plans for these circumstances. Since the current NASA authorization



and the likely appropriation would eliminate the CEV, NASA has been looking at other options to perform this effort. As noted earlier, these include the modified Progress option, which would offer the most capability, but NASA has not yet completed discussions with the Russians on how that could be done. The ASAP will continue to monitor this work in the coming year and report on the resulting plan in its next annual report.

With the ISS now more dependent on Russian partnership for logistics, crew transport, and possible deorbit (at either planned end-of-life or under emergency conditions), the ASAP feels that further analysis on the risks inherent in this single-source service scenario should continue to be assessed, and it will be a regular part of its activity in the upcoming year. We would expect, for example, to elicit some discussion from the ISS Program about the recent docking incidents and the assessment of their safety impact (if any). An assessment and review of the ISS logistics line of balance (LOB), which would give insight into risks potentially generated by one or more missed Progress visits, will also be an item of interest next year.

III. CONCLUSION

The ASAP believes that lack of clarity and constancy of purpose among NASA, Congress, and the White House is a key safety concern. Earlier this year, the President signed a NASA Authorization Bill that reoriented the Agency's human spaceflight efforts; however, NASA's future human exploration mission plans are uncertain. From the aspect of safety, the lack of a defined mission can negatively affect workforce morale and the ability to attract and maintain the necessary skill sets needed for this high-technology venture. Congress, the White House, and NASA must quickly reach a consensus position on the Agency's future and our Nation's future in space.

NASA is moving forward to establish the certification process for commercial crew transportation services, but even for commercial transportation to LEO, there are uncertainties about the acquisition strategy. A well-thought-out acquisition strategy is fundamental to the development of standards and requirements for commercial crew transportation. The development of a good acquisition strategy will be a challenge; however, the ASAP urges NASA to promulgate one as quickly as possible.

NASA possesses much human spaceflight knowledge that has been built over many years. This knowledge could be very useful to commercial transportation developers. Excellent work has been done across the Shuttle, ISS, and Constellation Programs, and this knowledge should be captured and managed so that it is easily accessible by a wide audience both inside and outside the Agency.

For the systems that will replace the Space Shuttle, the ASAP has been focusing on two interrelated questions: How safe is safe enough for human spaceflight, and how will that safety level be demonstrated? How should that requirement be communicated to designers and builders? This year, NASA established a set of safety risk tolerances for human spaceflight. In the Panel's view, the tolerances may not be as safe as modern technology can and should provide. The ASAP recommends that NASA reevaluate the LOC risk targets to determine if they represent the appropriate safety levels that are desirable and can reasonably be provided by future spacecraft, especially when factors such as the unknown-unknowns are factored into the equation.



It will be very important for NASA and the FAA to work together closely to provide Government oversight for commercial crew operations. A strong interagency partnership will provide benefits—NASA has almost 50 years’ experience launching humans into space, and the FAA has more than 25 years’ experience in regulating commercial space launches. The ASAP encourages NASA and the FAA to “practice” their new relationship during the commercial cargo-delivery and vehicle-development missions over the next several years.

A number of the Panel’s recommendations were related to the workforce—the NASA safety culture, workforce wellness, an alcohol testing policy, and astronaut health and longitudinal data—and the Agency’s infrastructure, particularly safety-specific issues related to facilities maintenance and improvements. The ASAP will be following up on these issues over the coming year.

As the ISS moves into its second decade in operation, this extraordinary feat of engineering will face many challenges—logistics support, crew transport, operational anomalies and EVAs, increasing MMOD risks, and deorbit issues—as well as increasing dependence on the Russian partnership.

In addition to continued concentration on the issues highlighted above, the ASAP plans to increase its focus on the ISS topic in the coming year, including further examination on the risks inherent in the single-source service scenario.



APPENDIX:

Summary and Status of ASAP 2010 Recommendations



REC. #	DESCRIPTION OF RECOMMENDATION	STATUS
2010-01-01	Research and Development of S&MA Tools. NASA should develop a process to ensure that technical safety tool development is identified as a priority when technology development opportunities are being evaluated for future funding.	NASA response received; remains OPEN pending briefing
2010-01-02	S&MA Technical Excellence Program (STEP). The NASA Safety Center (NSC) should continue to develop the remaining STEP levels (levels 2–4) for S&MA, and the NSC, in the process of doing this development, should take into account the changing nature of the S&MA roles within the new NASA organization.	CLOSED
2010-01-03	S&MA Analyze Changing Work and Skills Needed for the Future. NASA S&MA should take a leadership role in beginning to analyze how the S&MA work is going to change and what kinds of skills are going to be needed in the future.	NASA response received; remains OPEN pending briefing
2010-01-04(a)	Integration of Crew Requirements into Design—Vibration Limits. Research should be initiated to establish and codify crew vibration limits for various phases of flight for future space vehicles.	NASA response received; remains OPEN pending schedule
2010-01-04(b)	Integration of Crew Requirements into Design—Process. Develop and incorporate into the design process a more rigorous process for identifying, assessing, resolving, and integrating the crew’s desires and needs into the system design requirements for future vehicles.	OPEN
2010-01-05	Acquisition Strategy and Timeline for Development and Publication of Human Rating Requirements (HRR) for Commercial Activities. NASA should take action immediately to develop the acquisition strategy to guide the development of the HR process. The ASAP continues its long-standing recommendations that NASA develop the HR process for the commercial sector. The ASAP also recommends a more aggressive timeline for the development and publication of commercially-related human requirements.	NASA response received; remains OPEN for additional information on strategy vis-à-vis safety



REC. #	DESCRIPTION OF RECOMMENDATION	STATUS
2010-01-06	Knowledge Capture and Management. With the dismantlement of the Constellation Program, the Panel recommends that NASA begin now to find and to document the tacit knowledge and to organize the already documented explicit knowledge that has been learned and developed to date.	NASA response received; remains OPEN pending schedule
2010-01-07	Methodology for Performing Integrated Abort Risk Analysis and Development of Supporting Tools. NASA should prescribe the methodology for performing integrated abort risk analysis and develop the supporting tools as needed so that these types of analyses are performed uniformly across the industry.	NASA response received; remains OPEN pending briefing
2010-01-08	Leading Indicators for Industrial Safety. The MSFC S&MA organization should spend some time looking at leading indicators that other industries and organizations are using.	NASA response received; remains OPEN pending briefing
2010-02-01	Budget Authority for Facility Maintenance, Infrastructure Development, and Safety Upgrades for NASA Aircraft. The Mission Support Directorate should continue to identify safety-specific issues, not only in the three areas of maintenance, infrastructure improvement, and aircraft, but other areas that will have an impact on quantifying support and justification for further budget requirements.	OPEN
2010-02-02	Mishap Investigation Process and Plan. Each of the Center Directors should exercise leadership to make sure other Centers get mishap information.	NASA response received; remains OPEN pending briefing
2010-02-03	Taurus XL Mishap Documentation. NASA should examine the eleven Orbiting Carbon Observatory (OCO) findings and determine which of them can be codified in some way that can benefit other programs. Expand the process used to do that and integrate it into mishap investigation procedures.	OPEN



REC. #	DESCRIPTION OF RECOMMENDATION	STATUS
2010-02-04	Public Affairs Office Role. PAO should follow the advice that they give to NASA’s Program Offices. The PAO needs to become more integrated with the technical people. PAO should take more direct control of their work and play a bigger role.	NASA response received; remains OPEN pending update
2010-03-01(a)	Loss of Crew (LOC) Acceptable Risk Criteria. NASA should undertake an effort to reevaluate the LOC risk criteria to determine if they represent the best levels of safety that can reasonable be provided by future safety-optimized manned spacecraft. NASA should determine what the current threshold, design requirement, and goal numbers should be for the next refinement of safety risk requirements.	OPEN
2010-03-01(b)	Risk Requirements—Clarity and Communication. NASA should consider putting all the program requirements in one place so they are easy to find and simpler for configuration control. NASA should be more structured and faster in communicating changes to requirements or additional insight from analysis of requirements.	OPEN
2010-03-02	NASA Safety Center Agency-Wide Tracking of Safety Metrics. The NASA Safety Center should begin to report and track Center by Center comparisons of all metrics as well as the categorization of A, B, C, and D mishaps.	OPEN
2010-03-03	NASA Standards Update as a Result of the NASA Engineering and Safety Center (NESC) Engineering Assessments. The standardized format for NESC engineering reports should be modified to include a section at the end of each report that indicates whether any standards need to be modified or developed as a result of the assessment.	OPEN
2010-04-01	Workforce Wellness. NASA should consider the alternatives that are available within the legal and personnel system and examine the best efficiencies to encourage a regular exercise regimen among the workforce.	OPEN



REC. #	DESCRIPTION OF RECOMMENDATION	STATUS
2010-04-02(a)	Commercial Transportation Documents—Expression of Loss of Crew (LOC) Limits. NASA should publish threshold limits, objective limits, and goal limits to let commercial providers know what the ultimate number is. The goal limit should be put into the contract documents and agreements.	OPEN
2010-04-02(b)	Commercial Transportation Documents—Safety Language. NASA should specify the safety words to be used and their definitions, or at least show the correlation between industry and NASA terminology.	OPEN
2010-04-03	NASA Alcohol Use and Testing Policy. The lead Headquarters organization responsible for developing the alcohol policy is requested to provide a formal briefing on the status of the policy (including a schedule showing a targeted completion and implementation date) at the ASAP’s first quarterly meeting in 2011.	OPEN
2010-04-04	Timely Decision on STS-135. The decision on STS-135 should be made as soon as possible, and no later than the end of the calendar year.	OPEN

AEROSPACE SAFETY ADVISORY PANEL

Vice Admiral Joseph W. Dyer, USN (Ret.), Chair

Dr. James P. Bagian

John C. Frost

Deborah L. Grubbe, P.E.

John C. Marshall

Joyce A. McDevitt, P.E.

Dr. Donald P. McErlean

Dr. George C. Nield

