National Aeronautics & Space Administration

AEROSPACE SAFETY ADVISORY PANEL ANNUAL MEETING

March 25, 2003
NASA Headquarters, Washington, DC

MEETING MINUTES

original signed by

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Leonard B. Sirota
Executive Director

original signed by

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Shirley C. McCarty
Chair

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Ms. McCarty welcomed meeting attendees, stating that the purpose of the meeting was to present the *Annual Report for 2002* to Administrator Sean O'Keefe. The work involved in getting back to safe flight status will be dedicated to the crew of the *Columbia*. Each member of the panel introduced him- or herself, and Ms. McCarty gave guidelines for the meeting. Minutes plus the *Annual Report* will be available on the ASAP Web site, http://www.asap.nasa.gov.

2002 IN REVIEW—MS. MCCARTY

During 2002, four Space Shuttle flights were undertaken to continue construction of the International Space Station and one for repair of the Hubble Space Telescope. The Service Life Extension Program was initiated. Orbiter Major Modifications were moved to KSC; Support Engineering was moved to JSC. Not as many Boeing employees moved as had been anticipated, but the moves went smoothly. Of particular concern are the signs of an aging Shuttle fleet, and Space Station international partner cooperation. Pivotal issues, that is, issues that are critical to safety in NASA, are:

- Space Shuttle aging and certification
- Backlog of infrastructure maintenance
- Safety organization and processes
- Space Shuttle competitive sourcing
- Full-cost accounting

SPACE SHUTTLE PROGRAM—MR. SIECK

The spacecraft were originally designed to be certified for 10 years or 100 missions, with continual updating. The concept was that designers would certify the hardware and set up a system that updated the maintenance, test and inspection requirements throughout the lifespan. With the aging fleet (*Atlantis* is 18 years old; *Discovery* 17; *Endeavor* 11) and the increasing number of missions (average number of missions is 24), these requirements sometimes did not keep pace with the aging equipment. Examples of aging equipment include: finding small (a thousandth-of-an-inch) cracks in a 4-inch-diameter orbiter LH2 line (found by an especially thorough inspector, David Straight); hydrogen gas leaks from an ET H2 facility vent line on STS-110; and an open circuit in an orbital T-Zero umbilical connector, which precluded 12 ground pyro firings during STS-112 lift-off (redundant pyros did their job and lift-off proceeded safely), and a GO2 flex-hose leak which occurred in the payload bay during launch count of STS-113. In all cases the existing pre-launch maintenance, test and inspection requirements were properly implemented, but in hindsight the program proceeded into launch with hardware that was discrepant. At the very least, these cracks and other signs of aging caused delays in space flights.
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These vehicles were certified for launch because they had met minimum requirements. But this fleet, at some 20 years—all past their original certification–is in mid-life, so it is appropriate to do a mid-life recertification. Routine maintenance tests must be updated and refreshed. An analogy is the warranty for a car and parts; when the car exceeds its warranty it doesn't mean you stop driving it, but that you do various analyses, maintenance and testing.

Independent of age, the structural integrity of the airframe itself should be worthy and certified. The real issue is the need for a constant upgrade, improvement, and modernization program. e.g., the *B-52,* at 3 times the age of an orbiter, is still an active part of the Air Force's fleet. Aging here is not so much due to calendar time, but to lack of maintenance that acknowledges the effects of aging and the actual environment the hardware experiences. The original designers didn't fully understand the environment of continual vibration that the craft would be subjected to, or that cables and connectors installed 20 years ago would still be in use.

In light of the history of the first 10 years, the best way to handle the situation is system by system. The certification life numbers cited are targets, not exact figures. Therefore, "10 years" is no longer in the requirements because it's not relevant to the wear of all parts. An example is a cable that broke: they discovered that maintenance people were moving it often, which was not the environment anticipated when the cable was designed. All components must be recertified for the actual environment.

Mr. O'Connor noted that the original assumptions made about the environments encountered by the vehicles were not accurate in all cases. Given the real, now known environment, we should recertify the vehicles.

Findings and Recommendations

Recent significant hardware discrepancies, discovered late in the launch process or post flight, indicated that some certification processes and maintenance/test/inspection requirements did not totally acknowledge the hardware environment and aging effects.

- Revalidate certification requirements for critical flight and ground systems.
- Update the maintenance/test/inspection requirements.

The orbiter program is making progress in incorporating changes (EOs) into engineering drawings; nevertheless the backlog of EOs remains high.

- Identify drawings that are critical to flight safety.
- Update to include all EOs, and keep them current.

(This subject of Orbiter EO's was in the presentation material but was not briefed)

SHUTTLE CREW ESCAPE—MR. GUTIERREZ

The risk of flying the *Space Shuttle* is significant and inherent. The objective of safe return should be a probability of about 0.9999. Reality differs by an order of magnitude. Demonstrated rate of catastrophic failure is 1 in 57 or 1 in 88 depending on where you start counting. The probability of safe crew return is about 1 in 75 or 0.987. Potential safety upgrades offer only marginal improvement; no upgrades offer the 2 orders of magnitude improvement in probability of safe return that the JSC document requires. Ascent and descent are the riskiest times. At the same time, high-risk components—SRBs, thermal protection, main engines, and auxiliary power units—are inherent to the design.

Only full envelope crew escape offers significant improvement in the probability of safe return, and precedent exists: the *Discovery* escape capsule has already been used to return items from space; and many pilots have used the *B-58* escape capsule; and the European *Hermes* has an encapsulated ejection seat. NASA is flying something that's 2 orders of magnitude more risky than NASA's own documents advise. NASA should make a programmatic commitment to devising a crew escape system and should expedite its deployment or explain why a crew escape[e system is not being deployed.

Discussion

Mr. O'Keefe: Stopping flights is the only answer that guarantees safety. The larger question is philosophical: Is the risk of space exploration acceptable? Is the risk a consequence of being in an early stage of space exploration. Do we accept the risk; or do we say it's too risky and dispense with space exploration? This has been the question for every human endeavor since people lived in caves. If the answer is that we should continue space exploration, then we must accept some risk. Starting with an objective view, and not being driven by the desired outcome, we must look at ongoing studies and work to decrease the risk.

Mr. Gutierrez: The technology we're using is 40-years old. Technologies demonstrated 40-years ago should be able to be implemented today; and, with improved technologies, we should be able to do a better job today. Crew escape offers a unique opportunity to have our cake and eat it too because we can reduce risk significantly even if we can't improve the risk associated with the craft itself. The current system is a Phase I Crew Escape System that was developed following the Challenger accident; we were going to use this only in the interim until we built a Phase 2 system, but we have not done that. People outside the agency have been amazingly accurate in predicting the frequency and timing of accidents; it is likely that another accident–possibly two–will occur within the next 20-years.

Mr. O'Keefe: We must view the reality of the *Shuttle* program fungibly. Where we're heading is the Orbital Space Plane (OSP) in 10 years. We need to look at the larger context, not whether safety improves by a certain number or other variable. If we operate another 20-years, we will see the same amount of improvement as we've seen in the last 20-years. What if the *Shuttle* is used only for heavy lifting and OSP is used for crew transport? The Level I operational ideal would be to design an escape system into the OSP; maybe the answer is to use no crew in the Space Shuttle.

Dr. Harris: Some technological improvements have been implemented, but not all. Should the program stop now so we can look at the crew escape system? The next generation vehicle should have an escape system, but to achieve that, we need to do something to move in that direction right now, and so far we haven't seen NASA move in that direction.

Mr. O'Connor: The subtle implication of no commitment is that NASA and industry have given up because they couldn't find an answer in the past; therefore there is no answer.

Mr. Gutierrez: We recommend a commitment to crew escape. Getting past the "no commitment" enables a possibility of success. Furthermore, it's a concept that embodies technologies that have all been demonstrated.

Mr. O'Keefe: I've seen no evidence of malice, i.e., people who refuse to look at something because they don't see an immediate answer. At what point do you say I can't stand any loss? We need to look at a context broader than a series of design elements. It's not just a design option, but possibly an operational option. It's part of a future objective, but also part of a present objective. Moreover, we cannot be so "freeze-framed"; we must be receptive to possibilities that haven't even been thought of. Therefore, we really must complete the ongoing studies, independent of what has prevented their completion, and independent of guidelines for ratings.

Mr. Gutierrez: No malice was implied. We're not interested in recommending stopping human space flight: only in reducing the risk factor. We're losing people in space too often. Doing some crew escape in the orbital space plane program does not mean not doing crew escape in the *Space Shuttle,* i.e., one program should not depend on the other.

Mr. Gregory: Orbital Space Plane Level I will address crew survival, not necessarily crew escape.

Mr. O'Keefe: Level I Orbital Space Plane requirements include no specific requirement for an escape system, but rather a requirement for safety. This requirement is not constrained to a particular method. The method could be an escape system, a capability in the vehicle, or something we never thought about. We're not talking about crew escape, but crew survival by whatever means.

Dr. Harris: By doing this, we change the mindset of the existing culture, which is now focused on doing the most that we can technologically to ensure that the crew survives. If we don't start now, in a few decades, we'll be in the same place we are now.

Mr. Gutierrez: The heart of this recommendation is that we should concentrate on getting crew back instead of, as we do now, getting the vehicle back with the crew in it. The risk of space flight is significant and inherent. To lower that risk, we need a different culture, a different mindset. An analogy is the military fighter aircraft; it offers half a century of experience that escape systems improve the probability of escape.

Ms. McCarty: I would recommend that Mr. Gutierrez and Dr. Harris be involved in the NASA discussions about this issue.

Mr. O'Keefe: They are welcome to participate. Probability may not change with cultural change. We should put the full range of propositions on the table. We don't want to fail the responsiveness test, inferences over process, or to analyze intent, nor to be predispositive of anything. We want to forecast where we're going and be sure everyone understands what that entails.

Findings and Recommendations

Although progress is being made, there is no commitment to implementing crew escape capabilities for all regions of powered flight.

- Complete the ongoing studies of crew escape design options.
- Either document the reasons for not implementing the NASA Program Guidelines of Human Rating (currently in review) or expedite the deployment of such capabilities.

AVIATION SAFETY—MR. FRANCIS

NASA's process for mishap investigations is internal. There's good coordination and cross-fertilization among centers, but what about their independence? There could be conflicts. We would like to see more reaching out to include more independent accident investigation experts with varied expertise. The Mishap Investigation Board was selected, prior to the accident, from the Army, Navy, Transportation, and other agencies. We question selection of investigators by job title, i.e., billet—rather than practical experience, the way Adm. Gehman was chosen. By reaching out more, we would get a better investigation and also create and maintain the perception of independence.

Finding and Recommendation
NASA has a good policy of including individuals across Centers to participate in mishap investigations.
NASA's aviation mishap investigations would be strengthened by inviting truly independent advice from investigation experts outside NASA, such as the Navy, Air Force, Federal Aviation Administration, and the National Transportation Safety Board.

INTERNATIONAL SPACE STATION (ISS) PROGRAM—ADM. CANTRELL
We can't staff the *ISS* with more than 3 people until we have a crew return vehicle larger than the *Soyuz,* and Soyuz availability after 2006 has not yet been resolved.

Micrometeoroids and orbital debris threaten the *Space Shuttle* and the *ISS*. When the *Annual Report* was written, the funding for the NASA organization that performs Micro-Meteoroid Orbital Debris (MMOD) analyses and maintains a database of space debris had not been resolved under full cost accounting. However, this issue has now been resolved.

International partner agreements are needed to bridge gaps between various partners' philosophies regarding safety, e.g., the Russians sent volatile, toxic batteries into space. Existing agreements do not bridge these gaps, and we need effective agreements, processes and procedures. Progress has been made since the report was written, and the Panel will be interested in seeing this issue resolved.

Findings and Recommendations
The capability for crew return for a crew greater than 3, prior to the availability of the Orbital Space Plane remains unresolved.
- Continue the priority efforts to find a solution to the crew rescue problem in 2006.

FY 2004 funding for the essential safety elements of the Orbital Debris Program has not been identified.
- Resolve full cost accounting responsibility for continued funding of safety-related products of the Orbital Debris Program..

The existing documents and agreements among all international partners are not sufficient to prevent potentially hazardous material from entering the ISS*.*
- With full awareness and consideration of the existence of different interpretations and the apparent difference in philosophy relative to safety among all international partners, develop, negotiate, and document processes and procedures that will prevent potentially hazardous items from being flown to or used on the *ISS.*

COMPUTER HARDWARE AND SOFTWARE—MR. ZYGIELBAUM
Erroneous Cockpit Avionics Upgrade (CAU) displays may exhibit different data for different hardware and have the potential to cause hazardous crew actions. A hazard analysis for CAU has not been performed. When it is, hazard analyses should be considered within the CAU itself as well as in the context of the *Shuttle.*

International partner payload control centers must connect to operational systems. Maintaining the security of these information technology systems is a significant challenge because of wide distribution, many agencies, rapidly changing technology, and increasing threat. The Internet must be readily available but must be securely separate.

Findings and Recommendations

The CAU project has not completed a credible hazard analysis. An orbiter hazard analysis including the CAU has not been planned.

- Perform risk assessments and hazard analyses, both internal to the CAU and from the perspective of the entire orbiter, to confirm that there are no input error conditions that could result in flight crew actions detrimental to crew, mission, or vehicle safety.

Certain failure conditions may lead to conflicting data across display panels.

- Through analysis, assess the probability of conflicting data among display screens. Confirm through simulated flight experiments that flight crews are able to identify information conflicts, that they are able to ascertain correct parameters, and that they can correct these errors without undue impact to flight safety or operation.

The ISS *involves an interconnection of many computers and networks in the United States and abroad. Because of the large distribution, the many agencies involved, and the rapid advance of intrusion and security technologies, maintaining operational information system security is challenging.*

- Through negotiation and agreement, establish an unambiguous design that includes the security equivalent of air gaps around all operational computer systems, operational networks, and the Internet.
- Continuously ensure that information technology systems remain at the state of the art in security protection.
- Establish penetration team exercises and other tests to periodically (preferably continuously) measure and ensure the security of all operational computer systems and networks involved in the ISS, including those of all international partners. The panel specifically recommends using the National Security Agency in such exercises.

SAFETY ORGANIZATION AND PROCESSES—DR. LEVESON

NASA's reorganization has generated concern for independence and funding of safety processes. Safety oversight organizations no longer have independent lines of funding and reporting. There is a lack of safety engineering specialists within the systems engineering organization. Systems safety engineering should be reintegrated into systems engineering, with independent links back to Code Q. Currently, system safety tends to be performed late in the process. An appointment to a safety office is viewed as a dead-end assignment.

NASA has mandated root cause analysis, but application of the process varies among centers and organizations. This results in undiscovered problems, continued risk, and increased cost. The process should be changed from one of removing symptoms to one of removing underlying causes.

Findings and Recommendations

NASA has not established a guiding principle for locating safety organizations within its organizational structure. Unlike the Department of Defense and industry, NASA's safety organizations are integrated into the assurance organization rather than into systems engineering.

- Through appropriate management action, define an agency-wide safety organization structure—one that separates system safety engineering from system safety assurance.

NASA's safety policy direction is well formulated, but the Panel has observed that safety tends to be a comprehensive activity only late in the development cycle after design is complete, and occasionally only after an incident or mishap.

- Consider integrating safety into systems engineering to support system development and sustaining engineering and supporting system safety assurance through an independent reporting channel from the safety organization to the mission assurance organization.
- Establish independent funding mechanisms and appropriate authority, responsibility, and accountability for these new safety units.

NASA personnel do not view appointments to safety organizations as a positive career move.

- Require that managers of major NASA programs and projects have experience in safety organizations.

NASA's application of root cause analysis appears to be inconsistent across the agency and across programs.

- Continue the effort that has begun to assess the state of root cause analysis performed by NASA and its contractors. Provide the training and resources necessary to resolve any deficiencies.
- Explore the causes of cultural or contractual impediments and devise ways to change the culture from a fixing orientation to a learning orientation in which both cultural and organizational factors are included in the search for the source of problems.
- Establish an oversight process for reviewing the root cause analyses and the resulting recommendations for all major failures or incidents.

Human Capital Processes and Plans—Ms. McCarty

The Strategic Human Capital Plan developed by the Agency during the past year addresses many of the workforce issues that have been raised in the past five years. An issue of continuing and increasing importance is the impending retirement of about 25 percent of NASA's workforce in the next 5 years. This is occurring just as the U.S. pipeline of graduating scientists and engineers is contracting. This situation is similar throughout the aerospace industry and presents a significant challenge to NASA management. A competent, well-trained workforce is key to the success of the agency.

Discussion *Mr. O'Keefe:* This is the number 1 management issue; it's a serious actuarial problem worsened by the small cohort to recruit from. Fewer and fewer aspire to professions in aerospace, so we can't hope to replace people who retire—there are more graduates with a degree in exercise science than in engineering. In the last year NASA has developed a strategic Human Capital Plan with the Office of Personnel Management, the White House, and others. More importantly, we've done basic things like standardizing competencies and evaluating skill mixes. We must recruit on the front end, but we must also think about career opportunities. NASA has developed a set of legislative initiatives that must be passed by Congress. Regrettably, until Senator George Voinovich, Chairman Subcommittee on Oversight of Government Management, The Federal Workforce, and the District of Columbia, Committee on Governmental Affairs and Congressman Sherwood Boehlert, Chairman, Committee on Science came along, Congress had shown little interest, even though they admit that this is the highest management risk facing NASA as well as other government organizations. Panel members are encouraged to push this idea wherever and whenever they can. NASA concurs with the recommendation without reservation. The only proposed initiative that has not been piloted in a government agency is a scholarship-for-service program, an opportunity to sign on with NASA and get a degree.

Dr. Leveson: At the Massachusetts Institute of Technology, few students were joining the aerospace program in the mid-1990s, but now we're getting many more students, they're very interested in working for NASA, and all are interested in internships, etc.

Mr. O'Keefe: People want to work at NASA, but NASA is not flexible, even though salaries may be close to comparable. Graduates have education expenses and don't have flexibility, so whether they work for NASA may depend on something like moving expenses, or whether they can start immediately.

Ms. McCarty: NASA has an outstanding program to inspire students to pursue science and engineering educations.

Mr. O'Keefe: NASA has focused on educational initiatives. It's a longer-term workforce development issue, not just a personnel issue. We need an integrated approach with people who work together. The industry exchange piece of the legislation is very difficult to get through even though other agencies do it and it's a Best Practice. People need to get their hands dirty when they're doing systems engineering. They need to actually be able to do the jobs with the contractors. It would be different if we were trying to establish an academia exchange, but with industry, people fear ethics problems and conflicts of interest. Panel members should advocate industry involvement with NASA.

Mr. O'Keefe: The Navy Benchmarking lessons learned were particularly valuable immediately following the Columbia accident

WHITE PAPERS

This year, 15 white papers have been written; 2 are in progress. They are listed in the handout and summarized in the *Annual Report* at Appendix C.

NASA SAFETY SUMMARY REVIEW—MS. MCCARTY

For the first time, the Panel has provided a stoplight type overview of safety at NASA. This can be found at the beginning of the annual report. The issues covered have already been discussed.
Mr. O'Keefe: If we get back to flight expeditiously (maybe as early as Fall), NASA's intent would be to reset the schedule on ISS (we're 7 flights away from core completion), and the groundwork for dealing with continuous residence on ISS is being laid now. The agreements we have with our partners are indefinite, despite the fact that dealing with 16 different countries takes time and much negotiation. We must always keep an open mind and move in a constructive manner. How do we look at crew transfer, crew return requirements, and flight assignments that would enhance crew retention? After December, NASA began to let science determine the number of crewmembers. Even in the wake of the *Columbia* tragedy, it becomes more and more clear on how partnerships will have to work closely to make everything happen. NASA has moved faster in the last 6 months than in the preceding 2 years. The plan is vibrant and based on systems engineering, rather than on the calendar. Now there's no change in payload or anything else—we just want to start the calendar again.

QUESTIONS FROM THE PRESS AND THE PUBLIC

Unidentified person

I'd like clarification on the recommendation regarding crew escape.

Mr. O'Keefe: The *Annual Report* accurately states the recommendation. But, we should examine the larger question of whether we are willing to accept risk in order to pursue the space program.

***Patty Minor,* Houston Chronicle**

Mr. O'Keefe said he's thought day and night about the acceptable risk of human space flight since the *Columbia* tragedy. How does he feel now?

Mr. O'Keefe: I don't want to operate on gut response. I want to wait for review of investigators' independent study. The risk involved is not a new revelation. If they come back with a set of findings that would permit return to flight sooner, it would imply that the risk, while very high, is acceptable. If conclusions and findings show that risk is even higher than what we're talking about here, that would change the nature of the debate.

***Frank Morring,* Aviation Week**

There appears to be a plan to operate the *Space Station* with 2 people. Will this panel study that and the safety issues?

Ms. McCarty: Yes, tomorrow we have a meeting to lay out the schedule; a task leader has not yet been designated.

***Larry Wheeler,* Gannett News**

I heard Mr. Gutierrez say, "Put a crew escape system in the Shuttle before you fly it." I heard Mr. O'Keefe say, "We're going to study it." Please clarify.

Mr. Gutierrez: I didn't say don't fly before you put a crew escape system in. I said, flying without a crew escape system increases the risk.

Mr. O'Keefe: The debate is not a difference of view. A crew escape system may be an option that has to be dealt with, but it's only one part of the picture. It's a culture question, but one that should be guided by research and engineering for a substantive approach. Everybody is driven by the same objective, but let's not restrict the solutions. Ceasing flight is the only option guaranteed to prevent fatalities in space.

***Warren Leer,* New York Times**

How would the recommendation about a mid-life re-certification of systems on the *Shuttle* be accomplished?

Mr. Sieck: Not by shutting down the program, but by looking at the critical systems first, then at performance over the years and what was done when the systems were originally certified. We need to be sure that all the requirements were met and are still valid these many years later in light of experience with the actual environment. We must revisit those requirements, instead of assuming that what protected you on the last mission will protect you on the next one. The components would not have to be removed to test them. We already have a lot of data, and we need to look at it.

***Jeff Smith,* Washington Post**
Two questions: 1.) Would Mr. Gutierrez say more about the study he read after the *Challenger* accident that predicted more accidents? Why is he confident that escape systems could survive any situation? 2.) Mr. O'Keefe, based on studies to date, what is the minimum time it would take to retrofit an escape system?

Mr. Gutierrez: More than one study indicates that we will continue to lose vehicles at about the rate we're losing them and we shouldn't be surprised by future losses. Crew escape systems have not been robust enough to cover all possibilities, e.g., on entry. However, models without humans have survived. High sync rate and high dynamic pressure are not problems with the Space Shuttle. The biggest problem we face with the Shuttle is thermal. .

Mr. O'Keefe: For retrofitting, we're talking about months, not years. But constructing something like the sketch depicts is imponderable, and its feasibility hasn't been determined. Options that were the most extensively reviewed focused on the first couple of minutes and on reentry; neither is too survivable above 50,000 feet. Crew escape studies have to be revisited. Another problem was the size of the crew.

Mr. O'Connor: With 7 or 8, a payload bay thing might work or the forward fuselage could become the escape hatch itself; but that would be the most expensive (several billion dollars and several years per orbiter) and problematic to implement. The program has not committed to a crew escape design or strategy because that implies a schedule and allocated dollars. Coming up with something should be for all-human space flight, not just for the *Shuttle.* It's a bigger issue than just *Shuttle*.

***Alexander Souche,* Student at International Space Agency, France**
I offer 2 comments from a view outside NASA and outside the United States: 1.) Regarding foreign students, in Europe every student is interested in space and would like to work for NASA. 2.) A friend and I organized a youth space competition in Austria and in 12 weeks got 5,000 kids. This shows that you can implement outreach without a lot of money. At the end, we asked who knew about NASA—all hands went up; who knew about the European Space Agency (ESA)—half did; and the Austrian Space Agency—only the agency's representative and myself. The fact that everyone knows about NASA is an advantage of much potential. The question is how to transform that potential into recruitment.

APPENDIX A

Aerospace Safety Advisory Panel Membership

CHAIR
MS. SHIRLEY C McCARTY
Aerospace Consultant
Former Principal Director
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Member: August 2001 to Present
Consultant: February 1998 to August 2001

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Senior Policy Advisor
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Former Vice Chairman
National Transportation Safety Board
Member: August 2002 to Present
Consultant: February 2000 to April 2002

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Former Chief Engineer and Manager Space Shuttle Main Engine
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MR. SIDNEY M. GUTIERREZ
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Former Space Shuttle Commander
Member: August 2001 to Present
Consultant: April 2000 to August 2002

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President and Chief Operating Officer
Metro Machine Corporation
Former Commander in Chief
U.S. Atlantic Fleet
Member: August 2001 to Present
Consultant: November 1999 to August 2001

MR. ROGER D. SCHAUFELE
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Former Vice President, Engineering
Douglas Aircraft Company
Member: August 2001 to Present
Consultant: April 1997 to August 2001

MR. ROBERT B. SIECK
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Former Director of Shuttle Processing
NASA Kennedy Space Center
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Consultant: January 1999 to August 2001

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Co-Director, National Center for Information Technology and Education
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Member: March, 2003 - present
Consultant: August, 2001 to March, 2003

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Engineering and Technology Group
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August 2001 to Present

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Managing Director and Chief Engineer
RRB Associates, Inc.
August 2001 to Present

RADM WALTER H. CANTRELL, USN (Ret.)
Aerospace Consultant
Former Commander,
Space and Naval Warfare
Systems Command
May 2002 to Present

DR. H. CLAYTON FOUSHEE
Vice President and Partner,
Unisys Global Transportation
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DR. ULF G. GORANSON
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Former Space Shuttle Mission Specialist
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Former Payload Commander on STS-63
August 2001 to Present

DR. NANCY G LEVESON
Professor, Aeronautics and Astronautics
Massachusetts Institute of Technology
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