S. HRG. 108–985

COLUMBIA ACCIDENT INVESTIGATION BOARD'S REPORT ON THE SPACE SHUTTLE COLUMBIA ACCIDENT

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

SEPTEMBER 3, 2003

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

89–806 PDF WASHINGTON : 2014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

JOHN MCCAIN, Arizona, *Chairman*

TED STEVENS, Alaska	ERNEST F. HOLLINGS, South Carolina, *Ranking*
CONRAD BURNS, Montana	DANIEL K. INOUYE, Hawaii
TRENT LOTT, Mississippi	JOHN D. ROCKEFELLER IV, West Virginia
KAY BAILEY HUTCHISON, Texas	JOHN F. KERRY, Massachusetts
OLYMPIA J. SNOWE, Maine	JOHN B. BREAUX, Louisiana
SAM BROWNBACK, Kansas	BYRON L. DORGAN, North Dakota
GORDON H. SMITH, Oregon	RON WYDEN, Oregon
PETER G. FITZGERALD, Illinois	BARBARA BOXER, California
JOHN ENSIGN, Nevada	BILL NELSON, Florida
GEORGE ALLEN, Virginia	MARIA CANTWELL, Washington
JOHN E. SUNUNU, New Hampshire	FRANK R. LAUTENBERG, New Jersey

JEANNE BUMPUS, *Republican Staff Director and General Counsel*
ROBERT W. CHAMBERLIN, *Republican Chief Counsel*
KEVIN D. KAYES, *Democratic Staff Director and Chief Counsel*
GREGG ELIAS, *Democratic General Counsel*

CONTENTS

WITNESSES

APPENDIX

COLUMBIA ACCIDENT INVESTIGATION BOARD'S REPORT ON THE SPACE SHUTTLE COLUMBIA ACCIDENT

WEDNESDAY, SEPTEMBER 3, 2003

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 9:32 a.m. in room SR–253, Russell Senate Office Building, Hon. John McCain, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. JOHN MCCAIN, U.S. SENATOR FROM ARIZONA

The CHAIRMAN. Good morning. Last week, the Columbia Accident Investigation Board released its report on the causes of the space shuttle accident that occurred 7 months ago. Today the Committee will begin a thorough examination of its conclusions.

The Board's final report is one of the most comprehensive ever produced concerning the management and operations at NASA. It must serve as a wake-up call to NASA and to the Nation that we have, for too long, put off hard choices and forced the space program to limp along without adequate guidance or funding. As stated in the report, "Unless the technical, organizational, and cultural recommendations made in this report are implemented, little will have been accomplished to lessen the chance that another accident will follow." That's a very chilling and powerful statement, and I hope all Members of Congress will pay close attention to that statement, if nothing else in this report.

The report reminds us that we are still in the developmental stage of space transportation and that space is an unforgiving environment which challenges our technical expertise. It also raises a number of important issues that will have to be considered as we plan for the future of the space program. Most importantly, we will have to figure out where we want the space program to go and what we expect to get out of it. Then we will have to ensure that adequate and un-earmarked funds are provided for these missions. It is imperative that we eliminate wasteful spending and make efficient use of resources we commit to space exploration.

The Board worked tirelessly to identify and clarify the causes of this accident, and I'm deeply grateful to its members for their dedication. Although the technical causes of the accident have been suspected for some time, the Board's findings concerning the role

that NASA's organizational structure and culture played in this tragedy are as troubling as they are valuable.

As the Board reported, "Complex systems almost always fail in complex ways." The many factors that contributed to the accident largely demonstrate how far NASA has regressed—its incomplete and invalid impact analysis, its rejection to seek satellite images of the damaged shuttle, its reliance on past successes as a substitute for sound engineering practices, its organizational barriers that prevented effective communication of critical information and stifled professional differences of opinion, and its lack of integrated management across program elements.

The report further describes NASA's culture as including, "flawed decisionmaking, self-deception, introversion, and diminished curiosity about the world outside." We'll want to hear from Administrator O'Keefe about precisely how and when this culture can be changed.

I welcome Administrator O'Keefe and Admiral Gehman, and look forward to hearing their testimony on the Investigation Board's findings and recommendations and NASA's plan to return the space shuttle program to flight.

Again, I thank Admiral Gehman and his Board members for their outstanding work. I also think it's appropriate to note that Mr. O'Keefe and his staff were completely cooperative and helpful in the Board's investigation. That's not always true in the past. But I think they deserve credit for being helpful, even though sometimes it was obviously painful.

I'd like to turn to my friend of many years, and Ranking Member of the Committee, Senator Hollings, who, as we all know, made an announcement that he would not seek reelection. I know that Senator Hollings, until the last moment he is here, will continue to pursue with vigor, passion, and always non-controversially, issues that have interested him.

[Laughter.]

The CHAIRMAN. And I must say to my friend—he is not gone—but I and all Members of this Committee will miss him because of his long and outstanding and courageous service on this Committee and as a Member of the U.S. Senate.

Senator Hollings?

STATEMENT OF HON. ERNEST F. HOLLINGS, U.S. SENATOR FROM SOUTH CAROLINA

Senator HOLLINGS. I thank our distinguished Chairman and my good friend, John McCain. When I left town in the first of August, I was a bum. I had been serving almost—well, over 50 years in some public office. And as long as you continue to serve, you're a bum. But soon as I said I was going to get out of the way, I became a statesman.

[Laughter.]

Senator HOLLINGS. You ought to see the crap that——

[Laughter.]

Senator HOLLINGS.—that they put out. I mean, you've never seen such stuff.

[Laughter.]

Senator HOLLINGS. I mean, I've invented everything, I've thought of everything, and everything else of that kind.

[Laughter.]

Senator HOLLINGS. But it has been a distinct pleasure, and serving seven terms in the U.S. Senate is enough. I'm delighted to have an additional year here to see if we can straighten out a few things.

I commend Admiral Gehman and the Columbia Accident Investigation Board. For example, I was only reading last night, an article in the *London Economist* titled, "Old, Unsafe and Costly," the article detailed why it's time to "scuttle the shuttle." And that's exactly what you recommend, that the shuttle be scuttled.

However, I'm sort of intrigued with the findings regarding the culture of NASA. As an admiral, Mr. Gehman, you understand that a Navy board of inquiry, would immediately found responsibility, and whoever was captain of that ship would have been cashiered. I don't find that in the report—the fixing of responsibility. That intrigues me. If you were the coach of a football team, they'd buy up the contract, having lost seven members of the team.

Let me get right to the point. I think this Committee and the whole blooming setup is part of the culture. I've been here, as the distinguished Chairman just commented, for years, since we've had a Space Committee. Never have I heard anything about being unsafe.

I'll never forget when the *Challenger* went down. I talked to them out there at Morton Thiokol. If I remember the name, it was an Alan McDonald. And he said, "We told them, at the Cape, it was unsafe." With those O-rings, particularly the cold around there, and they were taking too great a risk." And he said, "There we all were gathered together in the hearing room there at Morton Thiokol, up there in Iowa, and when the *Challenger* blasted off, Jimmy said, 'There she goes.' And Henry said, 'Like a piece of cake.' And then all of a sudden she blew. And everyone in the room knew why. I said, "Mr. McDonald, will you come and tell the Committee that?" And he said, "I'd be glad to." They headed him off, and he never testified.

Now, we thought, after the Rogers Committee had gotten into it, that the Commission had cleaned it up, but, you didn't find it's been cleaned up. And we came with an independent safety office. But the independent safety office within NASA itself has not worked. We've lost seven astronauts.

So rather than part of the culture that you get up here on the Hill, "Oh, we're going to get them. We're going to get that. We're going to be back up in space." Uh-uh. We're not going to get up there until we get a decent shuttle and it's certified safe by others than in NASA, in my opinion.

I would hope that we had learned a lesson here, because we're the ones that put the pressure on Mr. O'Keefe. I know we all had worked with him on the Appropriations Committee, and when he got appointed that blooming Space Station was—or is, I think, about $40 billion, or $20 billion—that's right, it's about $20 billion over budget and about only 40 percent complete. So when we had the head of the Office of Management and Budget go over there, we were all concerned about money. We weren't concerned about

safety. So we're part of the culture right up here on this Committee. And rather than praising each other how thorough you have been—and it has been a very thorough—you all have really done a way better job than I thought was going to happen and get done. You all have really worked hard, and you've got a very comprehensive report, except the actual fixing of the responsibility.

Thank you, Mr. Chairman.

[The prepared statement of Senator Hollings follows:]

PREPARED STATEMENT OF HON. ERNEST F. HOLLINGS,
U.S. SENATOR FROM SOUTH CAROLINA

Thank you Mr. Chairman. I would like to begin by thanking Admiral Gehman and his colleagues for an excellent report. When you first came before this committee in February, some members wondered whether your group had the wherewithal to be critical enough of NASA. You reassured us then and the product of your work is excellent. Now we must begin the process of understanding and implementing your recommendations.

Mr. O'Keefe, I am glad that you are here as well. You certainly inherited more than you bargained for when you joined NASA. You have made the commitment that NASA will follow these recommendations. I hope so. I don't know how you will accomplish that, and the Board appears to have that doubt, too. Many of us have a sense of deja vu. We tried to change NASA in 1986 and now we know it just got worse. We have a NASA Administrator who is saying all of the right things, but having been here before we wonder if NASA can really heal itself or if Congress needs to step in—forcefully.

We have many decisions before us. First, we must ensure that we understand and have the proper insight into the return to flight process. What is the right thing to do and when should we do it? While NASA has appointed the Stafford-Covey team, I wonder whether this is enough. Perhaps we should have a Congressional Review Panel with experts appointed by the Congress to review this process.

These experts could also help us with our second task—provide a comprehensive, long-term vision for the space program. Here we are 40 years after the birth of space flight, and we don't have a very good idea of what we're doing and why, and what we are doing we aren't doing all that well. NASA made its goal to complete and service a space station, but even that's changed over the years. Regardless of what you think of the Station and I'm one who doesn't think much of it-the reality is that it's there and we need to service it. But it's time to think beyond Station. What's next for human spaceflight and what is a purpose to which we can all agree? Obviously, there aren't good answers to this question today.

Third, we need to figure out how to change NASA's culture. Admiral Gehman, your report was chilling on this point, and makes us wonder what on Earth we can do, particularly when the experts we relied on seemed to have failed us. The Rogers Commission that examined the *Challenger* accident recommended a strong, independent NASA safety organization, strong central control of the Shuttle Program, and broader participation by authorities who could ensure that safety was the highest priority. All that failed us, and NASA actively sought to unravel those changes. I understand your report argues that NASA was not just complacent and blind about safety, but was proactive about stopping safe, smart procedures on this mission-and still thinks its safety culture is top-notch. I think you said their culture was in denial. My gosh, what are we to make of all this!

The CAIB has once again recommended an independent safety office, as well as independent technical requirements management so that schedule worries don't impact decisions about what is safe to fly. My concern is that we have been here before and that NASA has a terrible track record. I'm not sure that NASA can reform itself. We in the Congress may need to help them, whether it's through new institutions or by changing the Program's responsibilities.

Finally, we'll have to figure out how to do all of this in an era of dwindling resources. It will take a lot of money to do this right. We need to weigh our options moving forward and make some hard choices. I look forward to working with you, Mr. Chairman, and the other members of the Committee to do just that.

The CHAIRMAN. Thank you, Senator Hollings. And, obviously, I would ask my colleagues to make their comments as briefly as possible, since we would like to hear from the witnesses.

Senator Hutchison?

STATEMENT OF HON. KAY BAILEY HUTCHISON, U.S. SENATOR FROM TEXAS

Senator HUTCHISON. Thank you, Senator McCain, Mr. Chairman.

First, I do want to commend the report, the open investigation that was done. I thank you, Admiral Gehman, for doing a great job. And I thank you, Administrator O'Keefe, for letting him do a great job. That says a lot, and it was very different from the *Challenger* experience. We appreciate that. Now we have a blueprint of where to go.

One of the most important things in your report concludes that the present shuttle is not inherently unsafe, but it does call for a massive recertification process to ensure flight safety. I will look to Administrator O'Keefe for his commitment to the project of recertifying shuttles before they go back in the air.

The report is a devastating attack on NASA's procedure and lines of communication. I hope that the Administrator regards this report as a blueprint for change, and I hope that it is acknowledged that there can never again be business as usual at NASA.

You cannot have your most innovative research, your most technologically advanced challenge done with a bureaucratic mentality. This doesn't mean you open the treasury, but it means you lock your vision on a few very big goals, and you do them right. "Faster, better, cheaper" should be thrown in the wastebasket.

When Senator Nelson and I, particularly, along with the whole Committee, asked questions of previous administrators, "Are we sacrificing safety?" we always got the answer, "Absolutely not. Safety is the first priority." Now we need to make sure that we have the vision, the scientific background, and the total change in the bureaucracy at NASA, from the very top to the very bottom, in line with the recommendations of the report.

Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Lautenberg?

STATEMENT OF HON. FRANK R. LAUTENBERG, U.S. SENATOR FROM NEW JERSEY

Senator LAUTENBERG. Thanks very much, Mr. Chairman. I will be brief. And I ask consent that my full statement be included in the record.

The CHAIRMAN. Without objection.

[The prepared statement of Senator Lautenberg follows:]

PREPARED STATEMENT OF HON. FRANK R. LAUTENBERG, U.S. SENATOR FROM NEW JERSEY

Mr. Chairman, thank you for holding this hearing.

The Columbia Accident Investigation Board's report is a critical document that will help those of us in Congress and the public understand the causes of the Columbia tragedy.

While there appears to be little disagreement about the physical cause of the accident, the troubling aspect of the report is that it forces us to ask some very difficult questions about the management of Federal programs and, the future of the space program itself.

This is not a time to simply assign blame—I believe we need to look ahead and learn from the lessons highlighted from this report. It's an appropriate time to ex-

amine the improvements needed to strengthen NASA's workforce and foster a *culture of open communication at NASA.*

I believe it's time to look at the effect that NASA's scheme of *outsourcing* work on this critical program has had on the *safety* of the program.

I have criticized this Administration for being content with buying "safety on the cheap" and "security on the cheap." We have seen this with the Administration's air traffic control privatization plan and its ill-fated proposal to cut air marshals.

With their zeal to "outsource," just how does the Administration prevent the budget cutters from cutting out safety and security protections with the slash of a pen?

But what has the Administration so fired up about its competitive outsourcing agenda is that it is touted to save money. The accident investigation report reminds us that "NASA led the way toward privatization, serving as an example to other government agencies." If this is truly the case, then I don't think the American people want other safety-critical work to be handled under a similar program structure.

It's been reported that at one time only about 1,800 NASA employees were responsible to oversee some 17,000 contractors. Those numbers have clear implications for the capacity of NASA to exercise appropriate oversight—to maintain the flow of vital information—and to assure full implementation of safety processes. This is not how our government should be run.

The desire to reach for the stars is as old as human history and the ambitions embodied in our manned space program are noble ones. But we have had *two fatal accidents* in 113 Shuttle missions. Many people have become inured to the dangers inherent in sending people into space and bringing them back safely. But the fact is, it's a high-risk venture. Some risk is unavoidable—that's what makes our astronauts such brave individuals.

Manned space exploration isn't cheap. If we try to do it on the cheap, we put safety and people's lives—at risk.

I'm sure we will hear in testimony today and in the future that safety has never been compromised. But NASA has always had problems overseeing its contractors. And the National Research Council has concluded that the contract to manage the Shuttle program awarded to United Space Alliance in 1996 contained financial incentives for investments in efficiency, but not for investments in modernization and safety improvements.

I look forward to hearing from our witnesses today—not just on the technical causes of the *Columbia* accident—but also on the organizational faultlines which promoted the potential for such a disaster like this. I also hope to hear testimony on NASA's relationship with its contractors, Congress's relationship with NASA, and an analysis of Administration budget requests for NASA past and present.

Thank you.

Senator LAUTENBERG. I would just like to make a couple of quick points. And my hat's off to Admiral Gehman and you, Mr. O'Keefe, for the very tough task that you took on, and the outcome that is described in your report, I think, is understandable and will have an effect on how we think about things in the future. And I hope that we will learn enough directly about the safety requirement so that something as terrible as happened here, the *Columbia* tragedy, will never happen again.

But I would go to something of principle and make a note of the fact that the privatization program that we see in government almost began with NASA. And now we see that we have some 1,800 people, I believe the number is, who are overseeing private contractors, in the multiple thousands, whether or not they have enough ability, enough structure to make sure that they're doing what they have to do.

And I'll close with this. On page 109 of your report, Admiral Gehman, "The major annual savings resulting from this spaceflight operations contract, which, in 1996, were touted to be some 500 million to a billion a year by the early 2000, have not materialized." And I highlight that, because throughout that paragraph it talks to the lack of success in achieving the cost efficiencies. And

what is it that permitted the costs to be overrun and still this terrible thing to take place?

And I hope, Mr. Chairman, that we'll find out about the relationship of the private side of the force and what impact it had. And I thank you very much and congratulate you again for the excellent work you've done.

The CHAIRMAN. Senator Sununu?

STATEMENT OF HON. JOHN E. SUNUNU,
U.S. SENATOR FROM NEW HAMPSHIRE

Senator SUNUNU. Thank you, Mr. Chairman.

I simply want to thank Admiral Gehman and Administrator O'Keefe for their work, and reiterate Chairman McCain's emphasis on the level of cooperation that was provided, the service of the members of the Board. I can't imagine an emotionally or physically more difficult task than the one that we gave to you, and we owe a great deal of thanks, of course, to the Board members, but also to the staff—the staff at NASA and the staff on the Board—that performed a lot of the more difficult tasks and probably spent at least as much time as the Board members themselves. So we're very grateful for your service and very appreciative of the work product.

The CHAIRMAN. Senator Wyden?

STATEMENT OF HON. RON WYDEN,
U.S. SENATOR FROM OREGON

Senator WYDEN. Thank you, Mr. Chairman.

And I think you, Mr. Chairman, and Senator Hollings have both put your hands on the central question, and that's looking again at NASA's mission. And my view is that you cannot resolve the issue about NASA's basic mission without looking carefully and in a fresh way at the direction of the manned space program.

And toward that end, Mr. Chairman and colleagues, I'd like to make a modest proposal this morning. I believe that, within 90 days or, at most, 6 months, NASA should prepare and furnish this Committee a cost-benefit analysis on the manned space program. What I would like to learn and what I think would be helpful to all of us in the Senate is to learn more precisely what can be accomplished with manned spaceflight and at what price, and what cannot. Once this information would be made available to the Committee, then we're in a position, I think, for the first time in a long time, to look carefully at how manned spaceflight fits into NASA's future and what can be accomplished with unmanned spaceflight that would also achieve the scientific discoveries that have been envisaged for the agency for some time.

There are other issues that I'm going to want to explore, but I intend to ask the Administrator about whether he would prepare a cost-benefit analysis quickly for the Senate on the manned spaceflight program. The other areas that I want to explore, particularly how this time we would ensure compliance with the Admiral's fine recommendations. I think if you look historically at this issue, after the last tragedy many of the same recommendations were made that Admiral Gehman is making now, and clearly many of them were not followed up on. I know that the Administrator,

Sean O'Keefe, feels strongly about this, as well, and I intend to ask some questions about how it's going to be different this time and the recommendations will be followed up on.

But I thank you, Mr. Chairman and Senator Hollings, for convening this hearing. I think the country wanted us to do this quickly, and you all have done that, and I thank you.

The CHAIRMAN. Senator Burns?

STATEMENT OF HON. CONRAD BURNS,
U.S. SENATOR FROM MONTANA

Senator BURNS. Thank you, Mr. Chairman. And I'll just submit my statement for the record.

The CHAIRMAN. Without objection.

Senator BURNS. I'd like to just offer a small comment. I, like the Chairman, appreciate the work that the Director has done and this Board has done. It took a great deal of courage to release the report that you did. It needed to be released. And it took a look at the inside of us, and we're going to have to reexamine just exactly what we found in there.

I think we now have to redirect our focus now on the vision and the R&D that goes along with NASA. We know that going into space will always be risky, at best. And so that work must go on. I think we will now look at different areas of a more moderate way to enter space and to move cargo. I think we'll take another look now at reusables and unmanned. I think, in our probes, our unmanned probes into the—further out in space is—they'll be a very important part of this Nation. And so we have a lot of work ahead of us. But, again, I want to congratulate you.

And, Senator Hollings, it may just seem like a year to you, but we'll miss you.

Thank you, Mr. Chairman.

[The prepared statement of Senator Burns follows:]

PREPARED STATEMENT OF HON. CONRAD BURNS, U.S. SENATOR FROM MONTANA

Thank you, Mr. Chairman, for convening this important hearing. It has been more than seven months since our Nation was shocked and deeply sorrowed by the loss of the Space Shuttle *Columbia* and its brave and courageous crew. As a long time supporter of NASA and of manned space flight, I was particularly concerned about the impact of the accident on our continuing endeavors in space. It was important for us to look into the cause of the accident in an objective and expeditious manner, and I believe that constituting the *Columbia* Accident Investigation Board was the right step to accomplish this goal. The Board had an enormous task, looking not only at where technology let us down but also human factors that may have contributed to this terrible tragedy.

The accident investigation team has concluded with a fair degree of confidence the sequence of events that led to the loss of the space shuttle *Columbia.* Technical problems, once identified, can be resolved with sufficient time and resources. What we continue to ponder and debate is what else can be done to better guard against such mishaps in the future. In looking over the investigation report, I was pleased to note that the Board has examined this issue as well, with a special emphasis on the existing organizational culture within our space agency.

The Board has put together a comprehensive report that includes 29 different recommendations, including 15 that must be implemented prior to any 'return to flight'. These recommendations, once implemented, will undoubtedly add a measure of safety to what is an inherently risky enterprise—space exploration will continue to challenge our technical capabilities just as it does our pioneering spirit. It is my hope that our Nation does not yield ground on either position.

As we analyze and dissect the findings of the report, we in Congress should be especially mindful of actions that signal our level of support for the space program.

Committing to human presence in space cannot go hand in-hand with under-funding and unrealistic expectations—these eventually contribute to the very culture that is alluded to in the Board's report. While additional oversight will help alleviate some of these problems, Congress must do its part to establish clearer priorities for our space agency. I hope that we continue to look at this issue in the days ahead.

Mr. Chairman, I applaud the efforts of the *Columbia* Accident Investigation Board in this obviously difficult task. I look forward to hearing from Admiral Gehman on the findings of the Board and from Mr. O'Keefe on his thoughts in this matter.

The CHAIRMAN. Senator Nelson?

STATEMENT OF HON. BILL NELSON,
U.S. SENATOR FROM FLORIDA

Senator NELSON. Mr. Chairman, I want to thank you for calling this hearing today. Thank you for your leadership in the oversight role that is going to be needed by this Committee as we proceed. And thanks to both of you gentlemen for the extraordinary leadership that you have offered.

Admiral Gehman, I particularly want to commend you, who I've worked with over the course of the past several months. Having read a lot of your interviews, having talked to your very professional staff, talked to the members of your Board, I think you have done an excellent work product.

I expected what you came out and talked about, the decision-making being influenced by the culture, and we need very much to attend to that. What I did not expect, but was pleasantly surprised in your report, that you addressed head-on, the question of the funding and how, over time—I can draw my own conclusions, as I have railed in this Committee on several occasions, that you can't do spaceflight on the cheap, that there are just too many things in a risky business that have got to be attended to, and particularly when safety is overlooked because money is siphoned off of the space shuttle program to put it onto something else, which has occurred over the past decade. And so thank you for bringing up that aspect.

And, Mr. Chairman, I will close by saying, again, thank you for the oversight hearings. And I think this is going to be extremely important, that in our oversight capacity, that although we can't lead the space program—that has to go all the way to the top, to the White House—we can certainly let, as Senator Hutchison has already said, our expressions of concern be known of what is adequately funding the program so that safety is not sacrificed like it has been.

We went through this drill 17 years ago, and safety was going to be number one. And it was, for about two or 3 years. And then the hard reality set in of siphoning the money off, of relegating the safety considerations—because of the day-to-day financial decisions, they were being relegated to the back seat.

So thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator Brownback?

STATEMENT OF HON. SAM BROWNBACK,
U.S. SENATOR FROM KANSAS

Senator BROWNBACK. Thank you, Mr. Chairman.

February 1, this country certainly suffered, and the world suffered, a terrible and tragic loss of the Shuttle *Columbia* and her crew, the seven astronauts that were explorers and they wished to serve their countries, and they did just that. While certainly saddened by the events that took place on that fateful day; however, true to this country's resolve, we've been determined to find and correct the cause and move forward. That is what this hearing is about today.

I believe it is imperative that America remains at the forefront of space exploration and discovery, and it's our job here in Congress to take this report, move forward expeditiously in getting America back in space safely aboard an American vehicle. I'm committed to authoring and working on reauthorizing a bill for NASA during this Congress and use this report to provide some of the guidelines for that bill. I'm also pleased to see that the Board recognizes the importance of a vision for America's future in manned space exploration. And I believe it's time for us to step back and to really review that and to establish that vision, and I'm hopeful we can see created a Presidential commission on the future of space exploration to establish a common vision for space exploration by America.

I've held several subcommittee hearings over the last few months, with not only NASA but other Federal officials, but also with the private sector companies and entrepreneurs in an effort to ascertain what America's vision for future space exploration should be. In all these hearings, one thing has stood clear: Americans continue to support human spaceflight and exploration. We cannot allow ourselves to give up and turn our backs on exploring space and the universe because we have suffered loss of life. Those are the risks we acknowledge and accept for the opportunity to improve the quality of life here on Earth and beyond.

We are tasked today with moving forward to ensure America's return to flight, and I'm anxious to hear what NASA's response is to the Board's report. But I'm also very interested in where they plan to go from here with America's vision in space exploration.

Thank you, Mr. Chairman, for holding the hearing.

The CHAIRMAN. Senator Breaux?

STATEMENT OF HON. JOHN B. BREAUX,
U.S. SENATOR FROM LOUISIANA

Senator BREAUX. Thank you, Mr. Chairman.

And let me join with all of our colleagues on the Committee who, I think, have a universal agreement on the quality of the work that was done, Admiral, after this great tragedy, and the cooperation, Mr. O'Keefe, that NASA had and the role that NASA played in working out this very detailed investigation of a very tragic set of circumstances.

It, indeed, is very tragic and is very, very high profile. If you think that we lose about 40,000 American lives on accidents every year on our Nation's highways, although this is an accident involving seven real American heroes, it really speaks to the essence of what America is all about. In a sense the quest for conquering outer space is really something that affects every American very

deeply when you see something so visible as the shuttle tragedy that occurred.

So I have a number of questions about the recommendations and the culture that, Admiral, you talked about, and how we change that. But let me just say now that the report, I think, is well done. And the cooperation, I think, that was exhibited is also to be commended. And I'll thank you both.

The CHAIRMAN. Senator Snowe?

STATEMENT OF HON. OLYMPIA J. SNOWE, U.S. SENATOR FROM MAINE

Senator SNOWE. Thank you, Mr. Chairman. I thank you for holding this hearing so promptly and responsibly. And I certainly want to welcome Admiral Gehman and Administrator O'Keefe here this morning.

This report, as everybody's indicated, is about moving forward, but the question is how we do so in a manner that honors the memories of those brave astronauts who lost their lives, and to prevent a reoccurrence of this tragedy from occurring in the future.

This report does, I think, represent a giant leap forward in understanding that which needs to be fixed. I think the question is the change that needs to occur and the implementation of that change.

And, Admiral Gehman, I want to congratulate you and the Board for your extraordinary efforts that you invested in developing this report, reaching beyond and not just ascertaining the last thing that occurred, but also understanding the whole system and patterns of failures and shortcomings. I think that that is essential for understanding the complete picture in order to address the inequities and also the failures overall.

I would also say that we know that this is—as you indicated, Admiral Gehman, "complex systems always fail in complex ways." So obviously the solution is going to be equally complicated. I think what becomes abundantly clear in this whole process is that the execution and the perpetuation of comprehensive changes must occur in order for the manned spaceflight program to continue, and prevent the loss of life in the future.

And I think we were all shocked by the revelations of the shortcomings, of miscommunications, obviously the bureaucratic misfirings. And I think, as a result, we have to know how and what must be done. But more importantly is establishing a perpetuity of vigilance in making sure that these things are implemented for the long-haul and the longevity that it's going to require. We cannot allow our outrage or concern to atrophy. You know, we have seen past reports, many of which were overlooked, and that cannot occur again in this instance.

And so when the spotlight is off, I would hope that we will be able to be assured that what has been recommended in this report is going to go forward. And it's not a question of just depending on previous successes, however tenuous, to predict future success. The question is, how do we create a permanent management structure that will enable NASA to succeed in the future with this program?

And I know we have a lot of remarkable people at NASA, and I know that your leadership, Administrator O'Keefe, and your ex-

traordinary work at the Board, Admiral Gehman, that it is possible and that when we look back at this time of tragic loss that we can view it as a turning point in the history of America's manned spaceflight program.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Inouye?

STATEMENT OF HON. DANIEL K. INOUYE, U.S. SENATOR FROM HAWAII

Senator INOUYE. Thank you very much, Mr. Chairman.

I wish to commend Administrator O'Keefe and Admiral Gehman for this careful, candid, and courageous report. Thank you very much.

I ask that the complete statement be made part of the record.

The CHAIRMAN. Without objection.

Welcome to the witnesses. We'll begin with you, Administrator O'Keefe. Thank you for appearing today.

STATEMENT OF HON. SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Mr. O'KEEFE. Thank you, Mr. Chairman.

I have a statement I'd like to submit for the record, if you would, and I'll briefly summarize.

The CHAIRMAN. And if you'd pull the microphone a little closer, please.

Mr. O'KEEFE. Sure. Is that resonating a little better?

Over our 45 years as an agency, when NASA was founded in 1958, we have found in the course of that history that our time has been defined by the great successes and the great failures. In each of these defining moments, our strength and resolve as professionals has been tested, to be sure. And this one of the seminal moments in our history. It is defined by a failure.

On February 1, we pledged to the families of the *Columbia* seven that we would find the problem, fix it, and return to exploration objectives that their loved ones dedicated their lives to. The Columbia Accident Investigation Board's report completes the first of these commitments, and we are indebted to Admiral Gehman and his Board members for their exceptional public service and extraordinary diligence in this difficult task. We wanted an unvarnished answer, and we got it.

As we begin to fulfill the second commitment to the families to fix the problem, our first step, critical first step, is to accept the findings, comply with the recommendations, and embrace this report. There is no equivocation on that pledge. This report, as many of you have observed, is a blueprint. It's a roadmap to achieve that second objective.

Now, in the course of the proceedings of this investigation, the Board has given us an extraordinary head start by their candor, their openness, and the release of findings and recommendations during the course of the investigation. This has all been conducted in a very open setting, and they have telegraphed all along the way, in the course of their public hearings, commentary, exactly

what their findings were as they found them and moved forward, and we've been listening.

So, again, to start, thanks to their good work and the manner in which they conducted it, in developing an implementation plan, and the implementation plan will be released here later this week with the intent to be updated all the time on the findings and recommendations—and you'll see that in this initial effort at it—and divided into two primary categories, the 29 recommendations of the Columbia Accident Investigation Board, and then a second approach, which is raising the bar to a standard higher than that. And we will include in that category everything and anything that's going to improve this process, as well as the capabilities of the hardware itself.

As we work through these recommendations, we'll have to choose options to implement them very wisely in order to be fully compliant with those recommendations, and we've got to continually improve and upgrade the plan itself to incorporate every aspect we find along the way in our implementation effort and any other observation, from wherever it may come, that needs to be addressed as we work our way through that in our commitment to fix the problem.

The report covers hardware failures and human failures and how our culture needs to change to mitigate against succumbing to failures of both kind. We must go forward and resolve to follow this blueprint, and do it in a way that is our very best effort, to make this a stronger organization. There is no question about that.

It will require all of us in the agency—not just the human spaceflight effort, not any one center, not any one program—all of us at NASA to recognize this is an institutional set of findings that has application to everything we do. And that's a profound set of recommendations. We wanted that unvarnished assessment, and we got it.

This is a very different NASA today than it was on February 1. Our lives are forever changed by this tragic event, but not nearly to the extent that the lives of the *Columbia* families have been changed for the rest of their time.

In taking inspiration from their approach, we must be as resolute and courageous in our efforts as they have been in working through this tragedy, and committing ourselves to accepting these findings, complying with these recommendations, and embracing this report. We know that how we respond in the days, weeks, and months ahead will matter as much as what we decide to do and whether there will be a lasting change that will withstand the years from now, I think has been observed by so many here, as well.

We must also resolve that definition and be definitive in our acceptance of our failures and in following through on our commitment to the families to fix the problem and return to the exploration objectives their loved ones dedicated their lives to. And in that effort we know we've got a lot of work ahead of us, and we've accepted that.

Thank you, Mr. Chairman.

[The prepared statement of Mr. O'Keefe follows:]

PREPARED STATEMENT OF SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Mr. Chairman and Members of the Committee, I appreciate the opportunity to appear before you here today with Admiral Gehman, who along with the other members of the Columbia Accident Investigation Board (CAIB) has selflessly performed a valuable and patriotic public service these past seven months.

Shortly after the tragic loss of the Space Shuttle and its heroic crew, I made a solemn pledge to the families of *Columbia's* crew that we will find out what caused the loss of the Space Shuttle *Columbia* and its crew, correct what problems we find, and safely continue with the important work in space that motivates our astronauts and inspire millions throughout the world. Thanks to the CAIB's thorough report, we now definitively know what caused the accident. It was a combination of hardware, process and human failures. We also have a more complete understanding of the problems that must be fixed at NASA to ensure that Space Shuttle operations are conducted as safely as humanly possible on behalf of our Nation's space exploration and research agenda.

Indeed, the CAIB has provided NASA with a very helpful roadmap for returning to safe flight activities, one that we intend to faithfully follow. I can assure you, that we will not only implement the CAIB's recommendations to the best of our ability, but we are also seeking ways to go beyond their recommendations.

Today's focus is on the hard lessons we've learned from the *Columbia* accident and about the hard work that lies ahead before we are ready to launch the Space Shuttle *Atlantis* for the STS–114 mission. I want to emphasize, as we undertake this work, we will be ever mindful of and appreciative of the people who have helped NASA and our entire country recover from that terrible first day of February.

First and foremost, we owe enormous gratitude to the brave families of the *Columbia* crew. Through their steadfast courage and dignity they have provided inspiration to the Nation. A fitting memorial for the crew will be constructed at Arlington National Cemetery. We thank the members of this Committee for your strong support of the Columbia Orbiter Memorial Act, which President Bush signed into law on April 16, 2003.

One month ago, the family members demonstrated an incredible spirit of exploration and discovery in their own right as they joined astronaut Scott Parazynski in climbing to the top of the recently named *Columbia Point,* a prominent vista on Colorado's Kit Carson Mountain that now honors the memory of the *Columbia* STS–107 crew.

We are also indebted to the over 14,000 people from the Environmental Protection Agency, Federal Emergency Management Agency, the Federal Bureau of Investigation, Defense Department, U.S. Forest Service, Texas and Louisiana National Guards and many state and local law enforcement and emergency service units who contributed to the recovery of *Columbia's* debris. As a result of this unprecedented interagency and intergovernmental cooperative effort, an area in eastern Texas and western Louisiana about the size of Rhode Island was carefully searched, resulting in the recovery of thirty-eight percent of the dry weight of the orbiter, including several key parts from the left wing, the part of the Orbiter damaged by a foam strike during liftoff, and the critical Orbiter Experimental Recorder—the data recorder that verified an validated much of what was learned about the accident from NASA's Mission Control during *Columbia's* reentry. We are deeply saddened to note that one of the helicopters searching for debris from the Shuttle *Columbia* crashed in the Angelina National Forest in east Texas on March 27 killing the pilot and a Forest Service Ranger. Our thoughts and prayers go out to the families of the helicopter crew members killed in the accident.

In support of this unprecedented operation, we received tremendous hospitality and support from the Texas communities of Lufkin, Hemphill, Nagadoches, Palestine and Corsicana, as well as the Louisiana communities of Shreveport and Leesville, particularly in support of activities at Barksdale AFB and Fort Polk. NASA vows not to forget the many kindnesses bestowed upon our people and the other recovery workers. We will use the resources and people of our Education Enterprise to help nurture the spirit of discovery and exploration in the young people who grow up in the region, just as we are working to help inspire and motivate school children throughout the country as they embark on their studies this fall.

Finally, we are grateful for the diligent work of the Columbia Accident Investigation Board members and staff. As many of you know, the Board has worked nonstop since they were given this important responsibility. Admiral Gehman has performed many tremendous acts of public service throughout his distinguished career, and I'm certain that the history books will regard his work on this report as among his most significant contributions to his country.

We accept the findings of the Board and will comply with their recommendations. The Columbia Accident Investigation Board's report recommendations will be our benchmark for return to flight. Using the Board's recommendations as NASA's organizing principles for emerging from the *Columbia* accident as a safer, stronger and smarter organization, we are in the process of completing a preliminary return to flight Implementation Plan which will detail the Agency's evolving blueprint for returning to flight safely and reliably. This Implementation Plan will be a living plan and will be updated on a regular and frequent basis, with input from across our entire Agency The plan will lay out how NASA will implement the recommendations of the CAIB, as well as a comprehensive set of self-initiated corrective actions.

Following the logic of the Board's report, our implementation plan strategy focuses on making improvements in the following key areas:

- *Technical excellence*—Making specific technical engineering changes that will enhance our overall technical capabilities. Among these changes is the establishment of our new NASA Engineering and Safety Center at the Langley Research Center in Hampton, Virginia that will draw upon talent throughout our Agency to take a no holds barred approach to mission safety. If people in the center spot a problem or potential problem during their engineering and safety assessments of all our programs, they will be empowered to get the entire Agency, if necessary, focused on finding and implementing solutions.
- *Management*—Putting in place more effective management procedures, safeguards, and decision-making processes.
- *Organizational Culture*—NASA recognizes that prior to the *Columbia,* mission cultural traits and organizational practices within the Agency detrimental to safety were allowed to develop. We will now work diligently to develop an organizational culture that reflects the best characteristics of a learning organization, one based on clear and open communications throughout our Mission Teams, with a management culture that empowers both dialogue and achievement.

At the same time the CAIB was developing its report, NASA pursued an intensive, Agency-wide effort to identify additional actions that will further improve the Space Shuttle Program. We took a fresh look at all aspects of the Program, from technical requirements to management processes, and developed a set of internally generated actions that complement and go beyond the CAIB recommendations. For example, some of the types of activities we are focusing on include rudder speed brake actuator inspections and re-evaluation of catastrophic hazard analysis, to name a few.

Our implementation plan integrates both the CAIB recommendations and our self-initiated actions. It is the first installment in a living document that will be periodically updated to reflect our progress toward safe return to flight and faithful implementation of the CAIB recommendations.

We are now determined to move forward with a careful, milestone driven return to spaceflight activities, to do so with the utmost concern for safety, incorporating all the lessons learned form the tragic events of February 1. That's exactly what we will do.

Our Return to Flight effort will involve a team of spaceflight professionals, led at NASA headquarters by Dr. Michael Greenfield, our Associate Deputy Administrator for Technical Programs and astronaut veteran Bill Readdy, our Associate Administrator for Space Flight.

Another astronaut veteran, Jim Halsell, who has flown on five Shuttle missions, will oversee the day-to-day work required for our return to flight. As the commander of an upcoming Shuttle Mission, STS–120, Jim has a very personal interest in ensuring we get Return to Flight done right. I can assure you we will also rely on the advice and judgment of all members of the astronaut corps, the men and women who have the most vested interest in safe operations of the Shuttle program.

We will also have the benefit of the wisdom and guidance of a seasoned Return to Flight Task Group, led by two veteran astronauts, Apollo commander Thomas Stafford and Space Shuttle commander Richard Covey. Members of the Stafford-Covey Task Group were chosen from among leading industry, academia and government experts. Members have knowledge and expertise in fields relevant to safety and space flight, as well as experience in leadership and management of complex programs. The diverse membership of the Task Group will carefully evaluate and publicly report on the progress of our response to implement the CAIB's recommendations.

There is another body that NASA will greatly rely on in the Return to Flight process: this committee, and the other Members of Congress who have a vital interest

in how NASA performs our work on behalf of the American public. We very much respect and value your oversight responsibility, and I personally look forward to working with you in the weeks and months ahead to ensure that we do our job right.

Building upon work already underway to address issues previously identified by the CAIB, the upcoming release of our preliminary Implementation Plan will mark an important step in our efforts to address and fix the problems that led to the *Columbia* accident. We are about to begin a new chapter in NASA history, one that will be marked by a renewed commitment to excellence in all aspects of our work, a strengthening of a safety ethos throughout our culture and an enhancement of our technical capabilities.

No doubt as we proceed along this path, all of us will be challenged. I am absolutely certain that the dedicated men and women of NASA are up to this challenge and we will not let the families of the *Columbia* astronauts and the American people down.

Finally, I believe it is important that all 13 CAIB members arrived at and agreed to the final conclusion of their report: "The United States should continue with a Human Space Flight Program consistent with the resolve voiced by President George W. Bush on February 1, 2003: 'Mankind is led into darkness beyond our world by the inspiration of discovery and the longing to understand. Our journey into space will go on.'"

Thank you again for the opportunity to appear before the Committee.

The CHAIRMAN. Thank you very much.

Admiral Gehman, I want to extend not only our appreciation to you, but to all members of your Commission, for the outstanding work they did. Welcome.

STATEMENT OF HAROLD W. GEHMAN, JR., CHAIRMAN, COLUMBIA ACCIDENT INVESTIGATION BOARD

Admiral GEHMAN. Thank you, Mr. Chairman. Good morning, Mr. Chairman. I'll just say a very few comments and ask that my opening statement be entered for the record.

The CHAIRMAN. Without objection.

Admiral GEHMAN. I thank the Committee for their compliments to the Board this morning, and on behalf of the Board, I accept your compliments. And I also know that the Members of this Committee share the feelings of the Board that the price this Nation paid on the first of February was so dear that it demands now that we do our part to ensure that an accident like this never happens again.

I would like to return the compliment to the Congress. As the Congress is aware, we were not a Presidential-appointed commission. But due to your oversight guidance and cooperation with this Board, the issue of our pedigree was removed from the table early on, and all the comments around town this week are about the merits of the report and not the process by how the report was written. And the Congress shares in the credit for turning that situation into a very positive situation, and I thank every Member of this Committee for assisting us.

I also would like to join in thanking my 12 colleagues, who essentially gave up 7 months of their life to do this report, and the over 100 full-time investigators and the thousands of NASA engineers and scientists who helped us with this project.

When I appeared before you on the 14th of May of this year, I made a commitment that our report would put this accident into context. There are many contexts, of course. There's the context of history, of budgets, of management, the context of what previous reviews of NASA have told us, and the context of our Nation's vi-

sion about human space travel. I believe that our report satisfies that requirement and has put this accident into all these contexts.

First of all, of course, we did establish the physical cause of this accident. The foam did it. And, by the way, for those of you who have never actually seen one of these objects, I brought it along. This object sitting on the floor over beside me, this is the famous left bipod ramp made out of the actual foam, and the little black line is approximately where the fracture occurred that caused this accident. So if you've never seen one, this is what one looks like.

Thank you, Tom.

The Board was very deliberate in coming to the conclusion that the foam did it. And the time that it took us to come to that conclusion allowed us to look rather introspectively and intrusively into management at NASA.

While we were working on the physical cause, we had many other people that were looking at how NASA did their business, particularly the space shuttle program. And we had to ask ourselves, "If the foam did it, was this a legitimate surprise, a new event that caught everybody by surprise? Or, if not, what is the history behind attempts to understand and fix this event if it was not a legitimate surprise?"

And what we found, of course, was that this was not a surprise. NASA had experienced this foam coming off many times in the past. And then when we got into the issue of learning how they dealt with this, in a scientific and engineering point of view, we got into the business about how the shuttle program handles unknowns, how they handle risk, how they provide for research or development to understand the processes that they're dealing with, and how they learn, as an institution. We were concerned with what we found. And that is really what—about half of our report is about what we found.

Being concerned with what we found, we then embarked upon two paths of investigation simultaneously. The first path was an academic review of how high-risk operations ought to be conducted and managed. And simultaneously we conducted a review to see whether or not there were practical instances where high-risk enterprises around the United States are being managed reliably and successfully in other areas. And we found plenty of cases where people deal with high-risk technology and high-risk enterprises, and do so successfully.

We took a menu or a recipe from the academic review and some examples from the best safety practices around the country, put them together in a template, and then judged NASA's space shuttle program by that template and found it to be wanting.

Our report then documents extensively, in detail, each of the issues that we are concerned about, along with documentary evidence, interviews, statements, pieces of paper, reports that support our conclusion. And also our report, we feel, concludes with specific actionable recommendations to make the shuttle operations more safe.

I'll conclude, Mr. Chairman, by adding one comment, because it was brought up by the Members several times, and that is the issue of accountability. The Board does not feel that people should not be held accountable for their actions. The Board does believe

in accountability. And we believe very strongly that we have included in our report plenty of documentary evidence to support accountability if the proper authorities want to hold people accountable. It's all in the report.

We decided long ago, made it public, and I have defended the position before this Committee before, that we were not going to make those judgments. But we put it all in the report. It's all there. If somebody, the Administrator of NASA or this Committee, wants to find out whose performance was not up to standard, it's all in the report and it should be fairly easy to sort that out.

We just elected that in order to pursue the issues that we wanted to pursue, we would be better off if we let the proper authorities take care of accountability and we did not come to the judgments. But we put all the stuff in the report.

Thank you, Mr. Chairman. I'm pleased to be here and ready to answer any questions.

[The prepared statement of Admiral Gehman follows:]

PREPARED STATEMENT OF HAROLD W. GEHMAN, JR., CHAIRMAN, COLUMBIA ACCIDENT INVESTIGATION BOARD

Good Morning Mr. Chairman, Senator Hollings, distinguished Members of the Committee.

I know members of this Committee feel as we on the Board do: that the price this Nation paid on February 1, 2003 was so dear, it demands we do our part to ensure an accident like this never happens again.

It is an honor to appear today before the Committee on Commerce, Science and Transportation. I thank you for inviting me to pay tribute to the legacy of Rick Husband, Willy McCool, Mike Anderson, Dave Brown, K.C. Chawla, Laurel Clark, and Ilan Ramon in presenting the findings of the investigation into the tragic loss of the Space Shuttle *Columbia.*

Before I begin, I would like to commend the efforts of my 12 fellow board members, 120 investigation staff members, 400 NASA engineers, and more than 25,000 debris searchers who have contributed immensely to the investigation.

Today I will provide the Committee with the final conclusions of the board with respect to the following three areas:

- The physical cause of the accident
- The organizational characteristics of NASA that contributed to the accident
- Recommendations the Board has made in regards to the Space Shuttle Program

I. Physical Cause

The Board has determined that the physical cause of the loss of *Columbia* and its crew was a breach in the Thermal Protection System on the leading edge of the left wing. The breach was initiated by a piece of insulating foam that separated from the left bipod ramp of the External Tank and struck the wing in the vicinity of the lower half of Reinforced Carbon-Carbon (RCC) panel 8 at 81.9 seconds after launch. During entry, this breach in the Thermal Protection System allowed superheated air to penetrate through the leading-edge insulation and progressively melt the aluminum structure of the left wing, resulting in a weakening of the structure until increasing aerodynamic forces caused loss of control, failure of the wing, and breakup of the orbiter.

Entry data demonstrated that the flaw in the left wing was extant prior to entry. The flight events are well documented, and establish that progressive destruction occurred as the orbiter entered the atmosphere. Superheated air damaged the structure of the wing first, leading to the abnormal aerodynamic forces that caused the eventual breakup. Once the orbiter began entry, there was no possibility of recovery.

The Board reached this conclusion after extensive analysis of five lines of evidence:

- The aerodynamic scenario
- The thermodynamic scenario
- The detailed system timeline from telemetry and recovered on-board recorder

- The videographic and photographic scenario
- Debris reconstruction and forensics

Additionally, the Board conducted foam impact tests in order to determine that this potential cause was indeed plausible. The tests proved this, and much more. The tests demonstrated that External Tank foam shed during launch could create considerable damage to the RCC panels and the tests also added to the body of knowledge regarding RCC strength. The foam impact testing ends for all time the common belief within NASA that foam strikes are just a flight turnaround issue, and also serves as a dramatic stimulus to change some people's attitudes about what we really "know." Furthermore, it demonstrates the Board's finding that the characterization of the Space Shuttle as operational rather than experimental was flawed. The direct result of this mindset was the lack of testing on such matters as the cause of foam shedding, the force of foam projectiles, and the strength of the RCC panels to withstand such debris strikes.

II. Organizational Causes

Mr. Chairman, the Board believes very strongly that complex systems almost always fail in complex ways. Most accident investigations fail to dig deeply enough into the causes beyond identifying the actual physical cause of the accident; for example, the part that failed and the person in the chain of command responsible for that failure. While this ensures that the failed part receives due attention and most likely will not fail again, such a narrow definition of causation usually does not lead to the fixes that prevent future accidents.

Our investigation into the loss of the *Columbia* was designed to get to the heart of the accident, and reveal the characteristics of NASA that allowed the accident to occur. As everyone knows, NASA is an outstanding organization, with highly skilled and motivated people and a long history of amazing accomplishments. However, there are long-standing management issues that led to the *Columbia* disaster.

The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle Program, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterization of the Shuttle as operational rather than developmental, and lack of an agreed upon national vision for human spaceflight.

Cultural traits and organizational practices detrimental to safety were allowed to develop, including:

- Reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements)
- Organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion
- Lack of integrated management across program elements
- The evolution of an informal chain of command and decision-making processes that operated outside the organization's rules

The Board believes that these factors are just as much to blame as the foam. We began an analysis of how high reliability organizations handle risky enterprises, creating a template for us to use to examine management and culture at the Space Shuttle Program. The Board has concluded that the Space Shuttle Program does not have the characteristics of a high reliability organization. Furthermore, history and previous studies demonstrate that NASA, as a whole, does not "learn" well.

The results of our very intrusive investigation into the Space Shuttle Program demonstrate clearly that gradually and over a period of many years, the original system of checks and balances has atrophied. Instead of using a system of checks and balances provided by independent engineering and safety organizations, the Shuttle Program placed all responsibility and authority for schedule, manifest, cost, budgeting, personnel assignments, technical specifications and the waivers to those specifications and safety in one office. That action created an office that could make programmatic trades to achieve whatever goals were set for it by a higher authority. For example, if meeting the schedule were priority number one, the program could trade safety upgrades against schedule. We find this to be an excellent system if one's goal is to know whom to blame if something goes wrong, but NOT an excellent system if one's goal is to maximize safety.

III. Recommendations

The Board does not believe that the Space Shuttle is inherently unsafe, and we were under no pressure to say that it was safe. However, there are things that must

be done to make it more safe than it is and many of these things must be accomplished before return to flight. Furthermore, if the Shuttle is to continue flying past the next few years, there are even more safety requirements necessary. Our recommendations and observations also constitute an attempt to find items that might be dangers in the future.

There are three types of recommendations in the report. The 15 Short-Term recommendations outline the fixes needed for return to flight. The 14 Mid-Term recommendations refer to the needs for continuing to fly for the next three to 12 years. The Long-Term recommendations discuss the considerations that must be made for continuing to fly the Space Shuttle beyond 12 years, including recommendations for replacing the Shuttle.

In addition to the cultural and organizational considerations that NASA must address, there are several recommendations that stand out. One of these is the call for NASA to take an integrated approach to the issue of the danger posed by debris by combining steps to reduce debris creation in the first place, an overall toughening of the orbiter, both in the RCC components and the other parts of the Thermal Protection System, including the tiles, and developing a capability for on-orbit inspection and repair. The Board studied scores of other findings of significance with respect to how exactly to prevent the next accident. Among the numerous recommendations is the need for better engineering drawings, better safety and quality assurance programs, and improved documentation. Additionally, there are specific ways to improve the orbiter maintenance down period without sacrificing safety, as well as recommendations on what to look for on bolt fractures, holdpost anomalies, Solid Rocket Booster attach rings, test equipment and training needs.

Conclusion

Mr. Chairman, during my last testimony before this committee, I promised a final report that places this accident in context, rendering the complete picture of how the loss of the *Columbia* fits into the complicated mosaic of budget trends, the myriad previous external reviews of NASA and the Shuttle Program, the implementation of Rogers Commission recommendations, changing Administrations and changing priorities, previous declarations of estimates of risk, workforce trends, management issues and several other factors. We have done this to the best of our ability and I believe we have succeeded.

It is our intent that this report be the basis for an important public policy debate that needs to follow. We must establish the Nation's vision for human space flight, and determine how willing we are to resource that vision. From these decisions will flow the debate on how urgent it is to replace the Shuttle and what the balance should be between robotic and human space flight, as well as many other pressing questions on the future of human space flight. Let the debate begin.

Thank you Mr. Chairman. This concludes my prepared remarks and I look forward to your questions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF THE ADMINISTRATOR
Washington, DC, July 23, 2003

Hon. JOHN MCCAIN,
Chairman,
Committee on Commerce, Science, and Transportation,
United States Senate,
Washington, DC.

Dear Mr. Chairman:

Pursuant to Section 9(c) of the Federal Advisory Committee Act (FACA) (5 U.S.C. App.), this letter is to notify the Committee that NASA establishing a Return to Flight Task Group. I have determined that the establishment of the Return to Flight Task Group is necessary and in the public interest in connection with the performance of duties imposed upon NASA by law. The Return to Flight Task Group will perform an independent assessment of NASA's actions to implement the recommendations of the Columbia Accident Investigation Board (CAIB), as they to the safety and readiness of STS–114. While the Task Group will not attempt to assess the adequacy CAIB recommendations, it will report on the progress of NASA's response to meet the of the recommendations. The Task Group will draw on the expertise of its members and other sources to provide its assessment to me, and will hold meetings and make site visits as necessary to accomplish its fact-finding. The Task Group will function solely as an advisory body and will comply fully with the provi-

sions of the FACA. A copy of the charter for the Return to Flight Task Group is enclosed.

The General Services Administration has concurred with the establishment of this Task Group and has approved its charter. The filing date for this charter under FACA is today. All information required by FACA is included in the charter.

We would be pleased to discuss the establishment of the Return to Flight Task Group with you or your staff.

Cordially,

SEAN O'KEEFE,
Administrator.

RETURN TO FLIGHT TASK GROUP CHARTER

Establishment and Authority

The NASA Administrator, having determined that it is in the public interest in connection with performance of the Agency duties under the law, and with the concurrence of the General Services Administration, establishes the NASA Return to Flight Task Group ("Task Group"), pursuant to the Federal Advisory Committee Act (FACA), 5 U.S.C. App. §§ 1 et seq.

Purpose and Duties

1. The Task Group will perform an independent assessment of NASA's actions to implement the recommendations of the Columbia Accident Investigation Board (CAIB), as they relate to the safety and operational readiness of STS–114. As necessary to their activities, the Task Group will consult with former members of the CAIB.
2. While the Task Group will not attempt to assess the adequacy of the CAIB recommendations, it will report on the progress of NASA's response to meet theirintent.
3. The Task Group may make other such observations on safety or operational readiness; as it believes appropriate.
4. The Task Group will draw on the expertise of its members and other sources to provide its assessment to the Administrator. The Task Group will hold meetings and make site visits as necessary to accomplish its fact-finding. The Task Group will be provided information necessary to perform its advisory functions, including activities of both the Agency and its contractors.
5. The Task Group will function solely as an advisory body and will comply fully with the provisions of the FACA.

Organization

The Task Group is authorized to establish panels in areas related to its work. The panels will report their findings and recommendations to the Task Group.

Membership

1. In order to reflect a balance of views, the Task Group will consist of non-NASA employees and one NASA non-voting, ex officio member, the Deputy Associate Administrator for Safety and Mission Assurance. In addition, there may be associate members selected for Task Group panels. The Task Group may also request appointment of consultants to support specific tasks. Members of the Task Group and panels will be chosen from among industry, academia, and government with recognized knowledge and expertise in fields relevant to safety and space flight.
2. Task Group members and the Co-Chairs of the Task Group will be appointed by the Administrator. At the request of the Task Group, associate members and consultants will be appointed by the Associate Deputy Administrator (Technical Programs).

Administrative Provisions

1. The Task Group will formally report its results to NASA on a continuing basis at appropriate intervals, including a final written report.
2. The Task Group *will* meet as often as required to complete its duties and will conduct at least two public meetings. Meetings will be open to the public, except when the General Counsel and the Agency Committee Management Officer determine that the meeting or a portion of it will be closed pursuant to the Government in the Sunshine Act or that the. meeting is not covered by the Federal Advisory Committee Act Panel meetings will be held as required.

3. The Executive Secretary will be appointed by the Administrator and will serve as the Designated Federal Officer.
4. The Office of Space Flight will provide technical and staff support through the Task Force on International Space Station Operational Readiness. The Office of Space Flight will provide operating funds for the Task Group and panels. The estimated operating costs total approximately $2 million, including 17.5 workyears for staff support.
5. Members of the Task Group are entitled to be compensated for their services at the rate equivalent to a GS 15, step 10. Members of the Task Group will also be allowed per diem and travel expenses as authorized by 5 U.S.C. § 5701 et seq.

Duration

The Task Group will terminate 2 years from the date of this charter, unless terminated earlier or renewed by the NASA Administrator.

SEAN O'KEEFE
Administrator

July 18, 2003
Date

STAFFORD-COVEY TASK GROUP

BIOGRAPHIES

Col. James C. Adamson, U.S. Army (Ret.)

CEO, Monarch Precision, LLC, Consulting firm

- Background: Astronaut (STS–28 & 43); President, Allied Signal Systems Technical Services Corporation, which later became Honeywell Technology Solutions, Inc. (retired, March 2001); Chief Operating Officer United Space Alliance (1995–1999). Current member, NASA Advisory Council Task Force on ISS Operational Readiness.

Maj. Gen. Bill Anders, USAF Reserve, (Ret.)

Retired Chair and CEO of General Dynamics Corp. (1990–1994)

- Background: Astronaut (Apollo 8); Executive Secretary of the Aeronautics & Space Council; Chairman of the Nuclear Regulatory Commission; Vice President of General Electric; U.S. Ambassador to Norway; Member, National Academy of Engineering; President, Heritage Flight Museum.

Dr. Walter Broadnax

President Clark University, Atlanta, Ga.

- Background: Just prior to coming to Clark, he was Dean of the School of Public Affairs at American University in Washington. Previously, he was Professor of Public Policy and Management in the School of Public Affairs at the University of Maryland, College Park, Md., where he also directed The Bureau of Governmental Research.

RADM Walter H. Cantrell, USN (Ret.)

Aerospace Safety Advisory Panel

- Background: Commander, Space and Naval Warfare Systems Command; Executive Director, Technology and Systems, and later President of Signal Processing Systems Division at Global Associates Limited; Program Director, Land Level Transfer Facility, Bath Iron Works, responsible for the design and construction of a $260M state of-the-art shipbuilding facility.

Dr. Kathryn Clark

Vice President for Education at TIVY, Inc.

- Background: Clark is also consultant in the fields of space, oceans and education. She consults for the Jean-Michel Cousteau Society, the National Marine Sanctuaries, and the Sea World—Hubbs Institute to enhance the study of oceans and marine wildlife and use the data for education and awareness of the environment of the seas.

Mr. Benjamin A. Cosgrove

Senior Vice President, Boeing Commercial Airplane Group (Retired)

- Background: 44 years at Boeing as engineer and manager associated with almost all Boeing jet aircraft programs, including chief project engineer and direc-

tor of engineering for the 767 program. Current member, NASA Advisory Council Task Force on ISS Operational Readiness.

Mr. Richard O. Covey, USAF (Ret.)

Co-Chairman, NASA Return to Flight Task Group

Vice President, Support Operations, Boeing Homeland Security and Services

- Background: Astronaut (STS–511, STS–26, STS–38, STS–61); test pilot; held key management positions in the Astronaut Office and Flight Crew Operations.

Dan L. Crippen, Ph.D.

Former Director of the Congressional Budget Office

- Background: Chief Counsel and Economic Policy Adviser to the U.S. Senate Majority Leader; Domestic Policy Advisor and Assistant to the President for Domestic Affairs; Senior Vice President of the consulting firm The Duberstein Group; Principal in the consulting firm Washington Counsel.

Mr. Joseph W. Cuzzupoli

Vice President and K–1 Program Manager, Kistler Aerospace Corporation

- Background: Aerospace engineer and manager for over 40 years. Vice President and Program Manager for Space Shuttle Orbiter Project for Rockwell International during development and served earlier as an Assistant Program Manager on Apollo. Current Member, NAC Task Force on ISS Operational Readiness.

Charles C. Daniel, Ph.D.

Engineering Consultant

- Background: Over 35 years experience as an engineer and manager in the fields of space flight vehicle design, analysis, integration and test at the Marshall Space Flight Center—from Saturn V to ISS. He was SRB flight operations lead for STS–1 through STS–8 and Chief Engineer for Space Station. Current member, NASA Advisory Council Task Force on ISS Operational Readiness.

Richard Danzig, Ph.D.

A Director of National Semiconductor Corporation, Human Genome Sciences, and Saffron Hill Ventures

- Background: Former Secretary and Under Secretary of the Navy. Former partner at the law firm of Latham and Watkins. Current Chairman of the Board of the Center for Strategic and Budgetary Assessments, Senior Fellow at the CNA Corporation, and member of the NASA Advisory Council.

Dr. Amy K. Donahue

An Assistant Professor of Public Administration at the University of Connecticut Institute of Public Affairs

- Background: Under the Intergovernmental Personnel Act, Donahue serves as Senior Advisor to the NASA Administrator for Homeland Security. She teaches graduate courses in public organizations and management, policy analysis, intergovernmental relations, and research methods.

Gen. Ron Fogleman, USAF (Ret.)

President and Chief Operating Officer of Durango Aerospace Incorporated

- Background: Former Chief of Staff of the United States Air Force. Managed the Air Mobility Command and served as Commander and Chief, U.S. Transportation Command. Current member of the NASA Advisory Council.

Col. Gary S. Geyer, USAF (Ret.)

Consultant

- Background: 35 years experience in space engineering and program management, primarily in senior positions in the government and industry. Served for 26 years with the National Reconnaissance Office. Named NRO 2000 Pioneer. Vice President for Lockheed Martin on major classified programs.

Maj. Gen. Ralph H. Jacobson, USAF (Ret.)

Consultant

- Background: USAF Assistant Deputy Chief of Staff for Space Shuttle Development and Operations and later as Director of Special Projects, Office of the Secretary of the Air Force. President Emeritus, Charles Stark Draper Laboratory. Current member, NASA Advisory Council Task Force on ISS Operational Readiness.

Mr. Richard Kohrs

Chief Engineer, Kistler Aerospace Corporation

- Background: Over 40 years of experience in systems engineering and integration of NASA Apollo, Shuttle, and Space Station programs. Managed the daily engineering, processing, and operations activities of the Shuttle program from 1985 through 1989. Director of Space Station Freedom in 1989 with overall responsibility for development and operation. Prior to joining Kistler in 1997, he was Director of the ANSER Center for International Aerospace Cooperation.

Susan M. Livingstone

Policy & management consultant

- Background: She serves as a member of the National Security Studies Board of Advisors (Maxwell School, Syracuse University), is again a board member of the Procurement Round Table and was appointed to NASA's Return-to-Flight Task Group for safe return of Shuttle flight operations.

Mr. James D. Lloyd

Deputy Associate Administrator, Office of Safety and Mission Assurance, NASA

- Background: Extensive background in system safety engineering and management for U.S. Army research and development programs. Came to NASA in aftermath of Challenger to help reconstitute the NASA safety and mission assurance program. Recently selected as the Deputy AA for the Office of Safety and Mission Assurance.

Lt. General Forrest S. McCartney, USAF (Ret.)

Consultant

- Background: Former Director of Kennedy Space Center (1986–1992). Lockheed Martin Vice President for Launch Operations, responsible for the Atlas, Titan, and Athena launch operations/activities at Cape Canaveral, Florida, and Vandenberg Air Force Base. USAF Program Director for several major satellite programs. Current Vice Chairman, NASA Aerospace Safety Advisory Panel.

Rosemary O'Leary J.D., Ph.D.

Professor of Public Administration & Political Science at the Maxwell School of Citizenship and Public Affairs, Syracuse University

- Background: An elected member of the U.S. National Academy of Public Administration, she was recently a senior Fulbright scholar conducting research on environmental policy in Malaysia. O'Leary was professor of public and environmental affairs at Indiana University and cofounder and co director of the Indiana Conflict Resolution Institute.

Mr. David Raspet

Consultant

- Background: Former senior manager, USAF, McDonnell-Douglas and Boeing. Experiences include leading the Future Imaging Architecture Space Segment IPT, and working on EELV Program Mission Assurance and Titan IVB–30 Readiness.

Dr. Decatur B. Rogers, P.E.

Dean Tennessee State University College of Engineering, Technology and Computer Science

- Background: Since 1988, Dr. Rogers has served as the Dean, College of Engineering, Technology and Computer Science and Professor of Mechanical Engineering at Tennessee State University in Nashville, Tenn. Rogers served in professorship and dean positions at Florida State University, Tallahassee; Fla., Prairie View A&M University, Prairie View, Texas, and Federal City College, Washington.

Mr. Sy Rubenstein

Aerospace Consultant

- Background: Former Rockwell International and McDonnell Douglas Employee. Served as President Rockwell International Space Systems Division responsible for Space Shuttle and Space Station activities. Former Vice President of Engineering and Orbiter Chief Engineer during the development and early operations of the Space Shuttle. Over 25 years of experience in the design, development and operation of manned space systems.

Mr. Robert Sieck

Aerospace Consultant

- Background: Former Director of Shuttle Processing, Kennedy Space Center. Served as Launch Director for 52 Space Shuttle launches and has been an engineer on aerospace projects including Gemini, Apollo, and the Space Shuttle. Current member of the NASA Aerospace Safety Advisory Panel.

Lt. General Thomas Stafford, USAF (Ret.)

Co-Chairman, NASA Return to Flight Task Group

President, Stafford, Burke & Hecker Inc., technical consulting

- Background: Astronaut (Gemini 6A, Gemini 9A, Apollo 10, CDR of the Apollo-Soyuz Test Project); Commandant of the USAF Flight Test Center; Deputy Chief of Staff, Research, Development and Acquisition at USAF HQ; served as a consultant to the President in various capacities and to NASA for the coordination of Shuttle-Mir activities. Current Chairman, NASA Advisory Council Task Force on International Space Station Operational Readiness.

Tom Tate

Vice President of Legislative Affairs for the Aerospace Industries Association (AIA)

- Background: With AlA, the trade association representing the Nation's manufacturers of commercial, military and business aircraft, helicopters, aircraft engines, missiles, spacecraft, and related components, he directs the activities of the association's Office of Legislative Affairs.

Mr. William Wegner

Consultant

- Background: Naval nuclear propulsion authority. Deputy Director to Admiral Rickover in Nuclear Navy Program. Founded Basic Energy Technology Associates and consulted in the area of civilian nuclear power plant safety. Board of Directors, Detroit Edison.

Executive Secretary, Return to Flight Task Group

Mr. David Lengyel

Executive Secretary, Return to Flight Task Group

- Background: Executive Director of the Aerospace Safety Advisory Panel. Former Manager of NASA's Moscow Technical Liaison Office. Several years' experience with ISS, Shuttle-Mir Programs. Extensive knowledge of Columbia Accident Investigation Board work.

The CHAIRMAN. Thank you, Admiral.

Mr. O'Keefe, it's a perfect segue into my first question: accountability. Culture needs to be fixed. How and when and what accountability do you expect to enforce here, in light of Admiral Gehman's statement that there's ample evidence of individuals, as well as institutions, that should be held accountable?

Mr. O'KEEFE. Yes, sir. No, I think, as I mentioned in the opening statement, the manner in which the Board conducted its activities was so open, so clear, in terms of their approach to it; and again the approach we used of releasing all the information that supported that investigative activity, has led to this result, and it's pretty clear, in terms of what's involved here, and we've been acting on that as we've moved through.

The shuttle program management team is a completely new team today, started—from the program manager all the way through all the key players, 14 or 15 of the senior folks are completely new folks in their capacities just in the last couple of months.

The CHAIRMAN. It seems to me that's half of accountability, Mr. O'Keefe. Have you held others accountable?

Mr. O'KEEFE. Yes, sir. As we've worked our way through this, there are a range of other participants in this, and I think what

you see is a management team in place that's different today than it was a year ago, to be sure, and certainly very different than it was 7 months ago. This is——

The CHAIRMAN. Does that mean that those who are replaced are accountable?

Mr. O'KEEFE. The folks who are in positions today will lead in the future and be accountable for this activity. Those who are not there, I think you can draw the conclusion from that.

The CHAIRMAN. When do you expect this culture to be fixed?

Mr. O'KEEFE. I think Admiral Gehman and the Board observed in the report this is going to be a long, long haul. There's no question about it. Again, the first step has got to be, without equivocation, that we accept the findings, we'll comply with the recommendations, and we'll embrace this report. That's the first critical step in moving toward the role of, I think, a full acceptance of a culture change.

And in doing so, I think that's going to take time. We've got to be very consistent in that message. We've got to be very consistent in the direction we're going to go. And any equivocation to that point, I think, is going to falter that effort. So we've got to be, on the long haul, proceeding in that direction. But I fully anticipate we will see the beginnings of that change within 6 months to a year, to be sure. And we've begun that process as immediately as the day the report released to assure that everyone understands there is no equivocation on accepting these findings, complying with these recommendations, and embracing this report.

The CHAIRMAN. Admiral Gehman, would you describe how Congressional earmarks and NASA's transfer of funding from the shuttle program to other programs and the declining NASA budget affected the space shuttle operations and safety?

Admiral GEHMAN. I certainly will. And we included in our report the plain facts of the matter, just so that anybody who wants to do the research can come to the conclusion that over a period of about a decade the buying power or purchasing power of the shuttle program has been reduced by over 40 percent.

Really, though, what has happened, in the Board's opinion, is the very insidious, the powerful but nearly invisible force of dissatisfaction—dissatisfaction among several administrations, dissatisfaction among several Committees of Congress, and even the Administrator of NASA—with the extremely expensive cost of operating the shuttle. It costs much more to operate the shuttle than everybody will ever admit, and over the years, what has happened is that, for one reason or another, people have tried to wring money out of the shuttle program in order to pay for other projects.

NASA has essentially been operating under a flat budget, that flat top line. In order to do other things, there has been a steady, consistent attempt to wring money out of the shuttle program, some of it legitimately, by efficiency and effectiveness. But, nevertheless, since the shuttle program is so expensive, there have been efforts to squeeze money out of the shuttle program.

It is the Board's opinion that the effect of this is that—for a number of years after the *Challenger* accident, the management scheme of the shuttle program has been changed to a very vertical scheme in which the program manager, over a period of years, had become

responsible for schedules, manifests, costs, budgets, personnel assignments, technical specifications and requirements, the waivers to technical specifications and requirements, and safety. And because people were naturally trying to get money out of this very expensive program, the program manager began to make trades in that trade space. And he began to trade things like research and development into why foam comes off, for measures to make the schedule. And he began to make trades like that. And the Board was very concerned that that was too much power in one person's hands.

If it is your goal to know who to blame if something goes wrong, having a scheme in which all of that responsibility is placed in the program manager's hands is a really good scheme if you want to know who to blame. But if you want to operate safely, our study of both the theory and the academics and the best business practices indicates you need to separate the engineering and the safety from the guy who's responsible for the cost and schedule, because inevitably they're going to fight with each other and you're going to get a conflict. And the person who is being hammered over cost and schedule is going to trade safety and engineering in order to achieve cost and schedule.

The CHAIRMAN. And Congressional earmarks?

Admiral GEHMAN. Congressional earmarks do a couple of things. One thing they do is, they give an overinflated number of the total value of NASA's budget, because there might be $400 million or $500 million worth of earmarks, but that's not really NASA's money to spend because they can't move it around. The administrator loses his flexibility. He can't buy more safety and all that kind of stuff.

Probably most of the earmarks that we looked at are actually adds. Most of them, but not all, were adds. But even if they were adds, it makes the NASA budget look bigger than it is, and it reduces the administrator's flexibility for moving money around.

The CHAIRMAN. Senator Hollings?

Senator HOLLINGS. Admiral Gehman, Mr. O'Keefe appointed you. Did you find him accountable?

Admiral GEHMAN. I did find him accountable, and I did find him to be cooperative, and I found him to take full responsibility for everything that happened on his watch.

Senator HOLLINGS. And by that answer, would you find him responsible for this "disaster," let's call it?

Admiral GEHMAN. I find that leadership—all leaders, including Mr. O'Keefe, including the Congress, including the White House—are responsible for the conditions that they set and that set for the conditions for the performance of their organization. Almost everything that we complain about—every management trait, every communications problem, every engineering problem that we complain about in this report—was set in motion between five and 15 years ago, so they didn't happen on his watch.

Senator HOLLINGS. It didn't happen on his watch?

Admiral GEHMAN. That's correct. Almost all of these traits that we're talking about are traits that happened from two to 5 years after the *Challenger* accident. That is, right after the *Challenger* accident, as Senator Nelson had indicated, all the energy and zeal

and diligence associated with the tragedy causes everybody to do their job really well.

Let me give you a case in point. The management of the human spaceflight program, which used to be in Washington, D.C., in the mid 1990s was shifted back down to Houston again. And Mr. O'Keefe brought it back up to Washington, as Rogers had recommended. That's an example of how we kind of migrated away from the Rogers recommendations.

Senator HOLLINGS. Admiral, I understand. But you've taken over a ship as a Navy admiral time and again, perhaps at a different rank, and you didn't put off what happened 15 years ago to the ship and 10 years ago to the ship. I'm not trying to embarrass anybody. We're all friends. But I'm trying to break past this "culture" finding and fix responsibility. And you have categorically said you didn't attempt to do that, fix responsibility. You have enough facts that would indicate they didn't hold safety up to standard. Now, Mr. O'Keefe has made a very categorical and convincing statement about, "We've got the message," and everything else that——

Mr. O'Keefe, right after this occurred, Chairman McCain and myself were informed immediately that they had tried their best to take images, take pictures of the damage done of the shuttle in flight. And I think it was two, perhaps three, times they—that is, the Defense Department—were ready to do it, but there was a formality about requesting it. And the request was made and then was canceled. In fact, I understand that Linda Hamm, the Chairman of the Management Team, was responsible. She consulted with Ralph Roe, the Manager of the Space Shuttle Vehicle Engineering Office, and that the imagery request having been made to the Defense Department was canceled by none other than Linda Hamm, who's now been just reassigned over to Houston in another office.

And, of all things, when you say, "I get it, or we're going to do it categorically, we're going to take every issue, we're going to do everything," we've put Mr. Roe as number two at the new safety office. That doesn't indicate to me that you've got it.

Mr. O'KEEFE. Yes, sir. Again, the approach we've taken here is to completely designate, for the management effort, the folks who are prepared to lead in the time ahead. And in dealing with the range of folks who participated in this activity—and clearly the report lays it out, as does Admiral Gehman's commentary—I think the approach we've got to take is put the best judgment to picking a leadership team for the program management office, as well as all the efforts we're engaged in here in Washington and across the centers toward this activity, and picking the best people to do that. That's who's in place today. This is the best leadership there. And that's the approach we've taken to this, and it certainly is a measure of accountability.

On that point, there is no question—and I appreciate Admiral Gehman's observation of this point—I am personally accountable for this. I view this as my personal responsibility. I serve at the pleasure of the President, at which point he decides that is no longer to his pleasure. I'm certainly ready to adhere to that. And my obligation between now and the time he may reach that decision is do my level best to assure that we accept these findings,

comply with these recommendations, and embrace this report, and we intend to do just that.

Senator HOLLINGS. Well, if that's the best you can do, is take Mr. Ralph Roe, who failed in safety and said, "I don't want the pictures. I don't want to find out about this safety," and make him responsible for safety. In fact, we all saw this on TV. NASA officials kept dissembling. We found all kind of defensiveness. We mentioned this last February when we had the hearing. And now we find out, having "got it," and making plans to do this and to do that, we've heard it all before. Senator Inouye, Senator Stevens, and myself were the only three on the Committee at the time of the *Challenger*. We heard all this before.

So there's no education in the second kick of a mule. I mean, I'm finding out and listening to the same thing I listened to 17 years ago, and we've lost seven astronauts. Now, they talk about an accident, but it was an avoidable accident. You talk about failures, but it was an avoidable failure. And here, to make sure that we don't have that same failure again you take the man who failed in safety and appoint him the number-two in the safety office.

Mr. O'KEEFE. Well, sir, no. Just to be technically clear about this, that's not the position he's assuming here. What we've set up and we're creating as of this time next month is an engineering and safety center which will perform, at least at minimum among these recommendations of the 29, trend analysis. In other words, be removed from the operational conduct of the activity and look at what the prior trends would be to see if we can identify those cases in which we have missed things. And we clearly missed the foam on this one. That's the point that's raised in this report very clearly. There were seven instances. And had we conducted that trend analysis, independent of the operational imperatives of flying the shuttle, we might have caught it. And that's what this new organization is going to do. And in that regard, we're trying to assemble engineers who will be removed from that operational activity and be able to step back with a fresh set of eyes, who are knowledgeable about the mechanics of this process and, at the Langley Research Center, organize all those disciplines among structures and aerospace engineers in order to look at those observable trends and see if we can identify what that next instance might be. And you need the folks who have got the experience to do that. And, in my judgment, to borrow a page from Wernher Von Braun, when you make a mistake you become that much more valuable the next time around to seeing exactly where that'll never be repeated again. And there's great value in some of that, and it's something we'll certainly test.

And let the measure of what we do be the final conclusion of your assessment on this, as opposed to what we say. If we follow through what we're saying we're going to do, let that be the measure of proof. And, in that regard, Senator, I view that as a very high standard we need to meet.

The CHAIRMAN. Senator Sununu?

Senator SUNUNU. Thank you.

Administrator O'Keefe, could you talk a little bit about the return-to-flight team—the makeup of the team, the timeline that they're going to operate under, and what you think their biggest

challenges will be in getting the job done before we can even entertain the idea of the shuttle returning to space?

Mr. O'KEEFE. Yes, sir. No, thank you very much for the question.

The return-to-flight team is composed and led by Colonel Jim Halsey, who's an Air Force colonel and an astronaut of four different flights previously. He is slated to be the commander of the STS–120 flight, which is six flights after the return-to-flight activity—had been slated before the accident—so he has a very, very strong vested interest in making sure we get this right. He is ably assisted by a very extensive team throughout the four spaceflight centers—Johnson, Marshall, Kennedy, and Stennis—in the effort in order to assure that we have pulled together all 29 of these recommendations, as well as, again, the raise-the-bar objectives that we've established. And it'll be included in this report, which we'll be releasing here later this week, early next, which encompasses and covers all of those recommendations plus all the observations and every other issue that we have come across to raise the bar, raise the standard that we're anticipating before we return to flight.

That's overseen by an internal senior management team of Bill Readdy, who is also a veteran astronaut, who is the Associate Administrator for Space Flight, and Michael Greenfield, who is the Associate Deputy Administrator for Technical Programs. And they're managing across the entire agency. So we gather all of the information from the other six centers that are not spaceflight related in dealing with this particular set of objectives. There's a range of capabilities we have across the agency, all of which will be brought to bear and employed, and there isn't any ambiguity, I think, among the leadership of the agency. This is all of our agency objective.

Finally, the oversight of our activities will be reviewed by a external panel led by Tom Stafford, a veteran *Apollo* and *Gemini* astronaut, and Dick Covey, who was the pilot on the flight immediately after *Challenger,* in September 1988, and 25 other experts in the fields of engineering, of management change, of culture change, academics, industry folks, the full range of background of management, as well as technical expertise, to assure that we have implemented these recommendations and that we have selected options that are compliant and will make this agency stronger.

All those folks are external experts in that regard. They have already met once. They've got the framework of the implementation plan. They'll meet again early next week. They'll be working through this all the way through that time and beyond our return-to-flight efforts. So we've got this at three different levels in order to assure that we are not singing ourselves to sleep on any individual solution here, or picking our favorite option at the expense of what may be a better approach.

Senator SUNUNU. Will their focus be on the 15 or so return-to-flight recommendations, or are they going to have a broader task of looking at all 29 recommendations plus the ones that, in your words, "would raise the bar" for NASA?

Mr. O'KEEFE. Yes, sir. The entire package. Everything. And we certainly—you know, I mean, taking the Board's statements absolutely literally, it says these 15 "must be implemented" prior to

that time, and we take that as being a fact, a finding, that we are not going to dispute and will certainly move toward. But nothing is being done on those 15 at the expense of all the others that are engaged in there. Because we may find, and we certainly have dealt with, a number of different aspects, during the course of aiding this investigation, that we believe rise to that same kind of standard of the 15, as well, that we will be implementing prior to return to flight.

Senator SUNUNU. Admiral Gehman, you talk about it, and the report, I think, is pretty clear, about identifying the causal relationship between the foam striking the leading edge of the wing and that leading to the accident. And just following this through the press and through the work of the Board, it's clear that a lot of technical effort went into assessing the cause of the accident.

My question, however, is, Where are the greatest uncertainties? I mean, we can't know everything about the accident. So where, in the mind of the Board, collective mind of the Board, are the greatest uncertainties with regard to the physical causes of the accident or the physical findings of how the shuttle came down?

Admiral GEHMAN. Well, the Board deliberated long and hard, and we had quite a wrestling match over the words that we would use to describe the physical cause. By that, I mean we could have used words like "all the evidence supports that the foam did it" or "the most probable cause is the foam did it," and we elected not to do that. We elected to say the foam did it. And that is based on overwhelming confirming evidence, multiple different avenues of investigation, all of which point to the same thing.

We do not have a picture of a leading-edge system with a hole in it. That would have been nice. That would have been confirmation that the foam did it. We don't have any such a thing as that. But we are absolutely, positively convinced, without—beyond a shadow of a doubt, of the physical cause of this accident, and there's no doubt in our mind whatsoever.

We were concerned, though, that in order for us to reach that conclusion we had to do some physical tests and conduct some tests that we thought NASA should have been doing all along.

Senator SUNUNU. There's no element of the system or the technical work that you did that frustrated the Board members? Again, absent a picture. But were there any other areas of technical investigation where you had to walk away, saying, "We don't have all the information we would like about the nature of the failure"—damage inside the wing, the way that the shuttle eventually came apart—no uncertainties there?

Admiral GEHMAN. Only one. Just one, and that is that—and it's in our report. There's a nice little chart in there that shows the roll-and-yaw moments that are reconstructed from the very extensive data recorders which are onboard the shuttle. And both of the roll-and-yaw moments show the shuttle left wing losing lift, due to damage, and roll and the yaw starting in one direction. And then, for some reason, one of them, the roll moment reverses, and we can't explain why that happens. It's probably due to a deformation of the wing of some sort.

But of the hundreds of pieces of technical data that we looked at, all of which point to a hole in the left leading edge, that's the only one that we can't absolutely scientifically explain.

Mr. O'KEEFE. Mr. Chairman, could I add just one point very quickly? The approach that the Board took that I found to be very impressive was, they never fell in love with one scenario. They, by process of elimination, worked their way through a fault-tree analysis that included every possible permutation, and then closed those avenues to reach the conclusions they did. So we're as informed by the things that they examined that have nothing to do with this accident, in their judgment, as we are about the things that they claim do have a specific contribution. Because there are a number of things they found that are equally problematic on some future activity unless we correct it. And so this is a very thorough, extremely extensive investigation that I believe in our 45-year history has never been conducted to this depth. Ever. And so it has uncovered a number of things that are extremely helpful in our pursuit of the return to flight, which has then informed that raise-the-bar set of standards of where we intend to go in our pursuit of return to flight when we're fit to fly.

The CHAIRMAN. Senator Lautenberg?

Senator LAUTENBERG. Thanks very much, Mr. Chairman.

And I start by saying to our friend and colleague, Senator Hollings, that your commentary this morning just confirms that we listen and listen carefully, have good things to say. And just because you're out of here doesn't mean that you have to go quiet. Just remember that.

[Laughter.]

Senator LAUTENBERG. And to you, Mr. Chairman, for holding this hearing and the hearings that we've traditionally had here have been very informative and very open. And, Admiral Gehman, I commend you. I haven't had a chance to fully read your report, but it's sprinkled with a candor that we rarely see in reports to government, because there's always a program to make sure that we don't attend this party or that party. And I think that you went right to it.

And how this particular tragic accident happened is critical because of the loss of life and the loss of confidence and all of those things. But more importantly is how did we get there in the first place? And when I look at the executive summary of your report and you say that, "the organizational causes of the accident are rooted in the space shuttle program's history and culture," that means there are things been going on for a long time, at least you felt so and so did your colleagues on the report who approved this statement.

The fact of the matter is that, in some ways, it was a tragedy waiting to happen, because I see in reports——

And, Mr. Chairman, I want to submit a report that comes from the International Federation of Professional Technical Engineers. It's their report on the effectiveness of NASA's workforce and contractor policies, and I think there's something to be learned from this. And I, again, ask the request that this be included in the record.

The CHAIRMAN. Without objection.

[The information referred to follows:]

International Federation of Professional and Technical Engineers, AFL–CIO

IFPTE REPORT ON THE EFFECTIVENESS OF NASA'S WORKFORCE AND CONTRACTOR POLICIES

March 2003

With the tragic loss of the seven astronauts on the shuttle *Columbia,* NASA is facing a challenge to its current role and future mission. Though the agency with the most ambitious scientific mission in the Federal Government has faced public scrutiny before, the tragedy provides an opportunity to evaluate and review NASA performance and management policies.

NASA faced serious challenges well before the recent *Columbia* tragedy. A combination of budget cuts, workforce downsizing, and contracting out of key NASA operations negatively affected the safety of NASA's manned space program, its ability to retain and pass along core technical knowledge, and its oversight of the contractor workforce. NASA's problems arose after the agency went through a drastic reorganization in the early 1990s. This reorganization was motivated in large part by the political pressure from Congress and the White House to replace government work with private sector contracting. NASA's senior management maintained that they could increase efficiency and performance while cutting its civil service workforce and relying on contractors to do the job. Yet, as the process of downsizing and contracting out proceeded, NASA workers, government reports and space policy experts warned of the consequences of performing critical projects, with little-to-no margin for error, with an insufficient budget and workforce.

The recent history of NASA's reorganization is all the more relevant in light of the Bush Administration's commitment of eventually contracting out half the current Federal workforce. Through the Reagan and Bush Sr. administrations, increasing political pressure to downsize government intensified. Under the Clinton administration, Vice President Gore drafted and directed the policy of "Reinventing Government," downsizing civil servant jobs and contracting out to the private sector that eliminated some 426,200 Federal jobs. NASA, which faced scrutiny for over-budget projects after the *Challenger* accident, was targeted for major cuts.

Under presidential and Congressional direction, NASA contracted out much of its work to achieve budget cuts. In 2003, NASA and all Federal departments and independent agencies are facing quotas to contract out work. The rationale cited by proponents of moving government work to the private sector is that the private sector is more accountable, has incentive to produce at lower cost, and more able to operate at higher efficiency. NASA's commitment to privatization extends to the most safety critical operations in the agency. Just before the *Columbia* accident, NASA commissioned a study on privatizing the entire shuttle operation, completely eliminating any NASA work on shuttle maintenance and operation. Yet there are no comprehensive long-term studies on Federal contracting, and there remains little evidence to support privatization proponents' argument that the private sector outperforms the Federal Government at a lower cost. However, NASA's example offers some insight to the problems that arise when Federal agencies rely heavily on contractors.

Today, with NASA relying increasingly on contractors than ever before, the *Columbia* shuttle tragedy and the issues surrounding NASA recall the *Challenger* shuttle accident in 1986, seventeen years before the *Columbia* accident. The Federal investigation into the *Challenger* accident revealed the complexities inherent in the NASA management contractor relationship and the decision-making process that involved both NASA and NASA contractor Morton Thiokol. Beyond the direct mechanical causes of the *Challenger* accident, that episode revealed larger administrative and managerial problems: the unclear accountability issues between contractors and NASA; NASA management's institutional pressure to maintain launch schedules (as promised by NASA to Congress); the lack of management control between managers; and the organizational layers between the civil service workforce and the contract workforce. While the *Columbia* investigation will likely take months to return conclusive findings, recent reports from within NASA and the Federal Government's investigative body suggest similar conditions currently exist.[i]

NASA Workforce and Its Critical Mission

At the onset of its creation in 1958, NASA used contractors to provide many of the services the agency needed. In 1962, NASA employed 23,000 civil servants and

used the services of 3,500 contractor personnel. By 1964, the agency had grown to 32,000 civil servants and 79,000 contractors. Although contractors played a significant role during the mission to the moon, the agency maintained a civil servant workforce to provide technical expertise, effectively manage contractors and perform operations. At that time, NASA also began using contractors when the agency could not find the talent to fill its workforce. Though contractors have historically played a role at NASA, the recent growth of the contractor workforce has made NASA into more of a contract management agency than a research and development agency.

NASA's contractors perform various services and provide the agency almost all aircraft and spacecraft. NASA always used contractors to build spacecraft, design hardware, and control some management functions. The NASA contracting philosophy stated that any work not related to planning and evaluation could and should be contracted out. This philosophy did not leave out the civil service workforce however. To understand and maintain the products and services purchased through contractors, NASA needed experienced engineers and scientists. Further, some scientific and engineering work has no equivalent in the private sector. Certain jobs, such as the astronaut corps, are part of the civil service and military because of their critical and governmental nature. NASA's civil service workforce also provided mission support services that had no equivalent in the private sector. Though NASA relied extensively on contractors to accomplish its Apollo moon missions and valuable aeronautics research of the 1960s, NASA managers, including eminent program director Werner Von Braun, questioned the use of contractors over in-house civil servants. Marshall Space Flight Center's Robert Gilruth, in a letter to George Mueller, Director of Manned Space Flight, claimed "the most effective management of future programs calls for greater in-house engineering capability."[ii]

While NASA kept the contractor workforce during periods of growth and shrinkage throughout the 1970s and 1980s, in the 1990s contractors at NASA increased significantly. Although the Federal Government keeps no official headcount of contract workers, data pulled from Federal contract information shows an increasing presence of contractors while civil service jobs disappear. In fact, while NASA aggressively cut costs in the 1990s and trimmed its civil service workforce, the ratio of contractors to civil service employees more than doubled. As evidenced in the data complied by Paul C. Light, a scholar at the Brookings Institute, NASA civil service jobs fell from 22,100 in 1984 to 20,100 in 1996. Meanwhile, workers employed through NASA contracts grew from 171,000 in 1984 to 350,600 in 1996. During the same period, workers employed through NASA grants increased from 7,700 to 26,900. After staying level throughout the late 1980s at approximately 21,000 full time civil servants, NASA's civil service workforce grew to 24,416 in 1991, then shrunk to a 40 year low of 17,500. The majority of the civil service reductions were achieved through buyouts, starting in 1995 and ending in 2000. With less than 13 percent of NASA's budget spent on its civil service workforce (including salary, benefits, and training), NASA has the second highest contractor to civil servant workforce ratio in the Federal Government.[iii]

These workforce shifts occurred as NASA's budget was cut under Daniel Goldin, NASA's Administrator from 1992 to 2001. He was appointed in 1992 by President Bush Sr. and directed to cut NASA's budget and bring the fiscal discipline of the business world to the Nation's premier science, research and development agency. Under the Clinton Administration, the NASA budget was cut for seven out of eight years. Goldin saved the agency some $40 billion under a management plan he called "Faster, Better, Cheaper" (FBC). While the principle behind FBC was vague and open to interpretation for most of Goldin's tenure, FBC attempted to "shorten development times, reduce costs, and increase the scientific return by flying more missions in less time." Using FBC as a way to contract out services and move more of NASA's resources into the private sector, Goldin eliminated much of the civil service infrastructure that monitored and held technical knowledge of the service and products contractors provided and oversaw NASA's safe and successful operation.

Critics of FBC always doubted NASA's ability to fulfill FBC without sacrificing either the "faster," the "better", or the "cheaper". Concerns became widespread after the highly publicized Mars missions failed in 1999. Further concerns arose as NASA's workforce reductions and increased contractor workforce, jeopardized the safety of space shuttle operations. Enough evidence existed in failed missions, close calls, and government reports that suggested the tradeoffs of FBC were inexperienced and reduced workforce capability; increased safety risks; and minor oversights that resulted in lost spacecraft.[iv]

In 2000, the Government Accounting Office (GAO) and the NASA Inspector Generals office took note of the safety lapses in the space shuttle program caused by the reduction of workforce. NASA's independent safety review body, the Aerospace

Safety Awareness Panel (ASAP), as well as NASA's Space Shuttle Independent Assessment Team (SIAT), later echoed these concerns. The studies pointed to one critical factor: while NASA reduced its space shuttle operating costs by $1.2 billion, or 30 percent, personnel reductions in its civil service workforce from 3,000 in 1995 to 1,800 in 2000 placed the shuttle at greater risk. A 3 percent spending increase came in Fiscal Year 2000 after space probe failures, repeated warnings about safety and understaffing, and a *Columbia* shuttle mission that included alarming malfunctions such as a short circuit and ruptured cooling tubes. Although NASA's budget has increased over the last three years, Congress still expects increased performance from an under-funded and understaffed workforce. In 2001 Congress, canceled some $530 million of the proposed $2.2 billion safety upgrades for the space shuttle fleet which were to span over five years.[v]

Goldin's NASA targeted the shuttle program for civil service workforce reductions and improved efficiency by consolidating the space shuttle's maintenance and reducing the civil service role to monitoring safety. In 1996, NASA handed over shuttle maintenance to the United Space Alliance (USA), a contractor partnership between Lockheed Martin and Rockwell (now Boeing). The six-year contract worth $8 billion was extended this past summer for two years for $2.5 billion. Currently some 6,000 USA workers oversee launch operations at Kennedy Space Center in Florida, while 4,000 workers at Johnson Space Center are USA employees. Thus, contractors, not NASA employees, do the majority of the space shuttle work.

In 1999, NASA's SIAT cited concerns that the space shuttle's safety is eroding due to workforce problems. While both NASA and contractor employees hold safety in the highest regard, the SIAT report found that "the workforce has received a conflicting message due to emphasis on achieving cost and staff reductions." With a reduced workforce directly involved in maintenance of the shuttle fleet, NASA could only perform safety monitoring, without much control over contractor procedures.

With a smaller civil service workforce, the GAO found that NASA is unable to properly monitor contractors' adherence to safety guidelines. Furthermore, NASA lost technical competence during the workforce reduction process, as senior employees departed before new civil service employees and contractors could learn from them.

In testimony before the House Subcommittee on Space and Aeronautics on April 18, 2002, ASAP Chairman Richard Blomberg spoke of the "strongest safety concern the Panel has voiced in the 15 years [Blomberg] was involved with it." In the 2001 Annual Report, the ASAP—a NASA safety watchdog created by Congress in 1967, after a launch pad fire claimed the lives of three Apollo 1 astronauts—stated, "inadequate budget levels can have a deleterious effect on safety." From 1999 to its latest report released in 2002, ASAP cited grave concerns for the safe operation of the space shuttle. According to the report, along with budget and personnel cutbacks at NASA throughout the 1990s, contractors at NASA also provided their services with a reduced workforce. Regarding NASA's consideration to further privatize the space shuttle operation, ASAP noted that such a move would inherently introduce new risks to safe operation.[vi]

Downsizing also has implications for the future of NASA's workforce capability. Although NASA halted its downsizing by 1999, its in-house competency had suffered greatly. A 1999 internal assessment of its workforce found NASA experiencing skills shortfalls in avionics, mechanical engineering, computer systems, and software assurance engineering. GAO also brought attention to much needed space shuttle safety upgrades that had not been budgeted. By 2000, GAO reported that NASA's downsized civil service workforce was stretched thin and overworked.

Fallout From Downsizing

As a result of extensive downsizing and contracting out as much as possible, NASA is facing a critical human resources problem: how to replenish a soon-to-retire workforce. While costs have been cut, its workforce is weaker and less experienced. The civil service workforce has to do more tasks with fewer staff, and the contractor workforce is working overtime due to their own staffing shortages. Though NASA hired 200 full-time workers for the shuttle operations in 2002, the shortfall remains. During the downsizing of the 1990s, 14,268 civil servant employees left NASA, while only 8,173 employees were hired. Hiring new workers brings with it new challenges. Training new staff and incorporating them into the work processes and structure of NASA will take a great commitment of resources and time.[vii]

NASA's workforce demographics are expected to compound the problem further. Within NASA's science and engineering workforce, those over 60 years old outnumber the under 30 population by a ratio of 3 to 1. With 15 percent of science and engineering employees currently at retirement age and another 25 percent eligi-

ble within the next 5 years, NASA has begun tracking skills, competencies, and measuring what skills are lacking in the workforce. However, as the GAO reported to Congress in 2002, new hires needed considerable training and faced the challenge of having to replace more experienced workers, and staffing shortfalls are expected to continue if not worsen.[viii]

NASA also faces the challenge of recruiting engineering and science talent away from higher paying private sector jobs. With many of NASA's operations in high-cost labor markets, NASA's salaries can be as much as $20,000 below private sector jobs in the same market. NASA also looses recruits to the private sector because the hiring process can take up to six months. Though NASA is looking to implement incentives to attract, retain and replenish their aging workforce, its budget has limited their implementation. Furthermore, incentives to retain experienced workers would also be necessary for new hires to gain knowledge from the experienced workers. The obvious solution of providing *competitive* salaries for *all* NASA employees has yet to receive serious political attention.[ix]

With NASA's workforce is stretched thin, work conditions have deteriorated. Recent GAO reports on NASA concluded that the civil service workforce is "showing signs of overwork and fatigue as a result of downsizing." Unmanned space launch failures in 1998 and 1999 have been attributed to overworked civil service employees. Overstressed and overworked employees at NASA's contractors also played a role in recent failures and safety lapses.[x]

Though NASA is looking to contractors to fill the workforce gap, various studies have reported the unintended consequence of using contractor employees over ci vii servants. The SIAT reported that it "feels strongly that workforce augmentation must be realized principally with NASA personnel rather than with contract personnel." The report found instances where important technical knowledge was possessed by only one civil servant. If that employee were to leave NASA, that technical knowledge leaves NASA as well.[xi]

Contractors, Safety, and Performance

For over twenty years, presidential administrations have planned for NASA's privatization. Though previous plans to privatize the shuttle fleet in the 1980s were placed on hold after the *Challenger* accident, the Reagan Administration set the course for NASA's privatization. In 1984, Congress amended NASA's charter "to seek and encourage to the maximum extent possible the fullest commercial use of space activities." Under Goldin, NASA moved to privatize both manned space programs, the space shuttle and the International Space Station (ISS). In 1998, Congress passed the Commercial Space Act with bipartisan support. The law forbade NASA from building space launch vehicles and directed NASA to plan for the privatization of the shuttle and the ISS while encouraging private sector development and operation of future reusable launch vehicles.[xii]

NASA's most apparent attempt to privatize major operations is the space shuttle. In 1995, a NASA commissioned study called the Kraft Report recommended that shuttle operations be contracted to one single contractor. The report cited that restructuring of the shuttle program was needed to reduce an overabundance of engineers and man-hours spent on each shuttle mission. The report suggested the shuttle could now be considered "operational" rather than "experimental," suggesting risks associated with the shuttle had been mitigated since the *Challenger* accident. The report concluded with a recommendation that a consolidated shuttle operations contract could serve as a precursor to "further industry involvement and progression toward the privatization of the space shuttle." [xiii]

As a result of the Kraft Report, NASA awarded a non-competitive contract for shuttle flight operations to a joint-venture by Lockheed Martin and Rockwell called United Space Alliance (USA). Boeing acquired Rockwell's space business in 1996 and took its place in USA. Though the intended goal of reducing costs was achieved, the contracting of NASA's most safety-critical operations had repercussions.

After NASA awarded USA the shuttle operations contract, many commentators and investigative reports warned of the potential dangers of increased privatization. Criticism came from within NASA, as well as outside critics, warning of the workforce and safety implications. Space policy analyst John Pike of the Federation of American Scientists predicted the reports' recommendations would one day be considered as "the turning point that led to the next shuttle accident." Apollo Astronaut John Young warned "you can't reduce people without introducing a lot of risk because you just work people too hard." In a letter to President Clinton, Jose Garcia, a NASA manager with over 30 years of experience expressed urgent concern regarding the pressure to downsize the workforce and extensive contracting of shuttle operations. Because "the shuttle is a complex R&D vehicle that requires NASA to play an important oversight role", Garcia wrote to Clinton, "it would be better to cancel

the manned space flight program than to recklessly endanger a future shuttle and its crew" by contracting out and reducing NASA's role in shuttle operations.[xiv]

During the past two years, NASA has been moving closer toward privatizing shuttle operations. A 2001 study conducted by a NASA team at Johnson Space Center concluded that compete privatization of the space shuttle was necessary as NASA's workforce entered retirement. Under a privatized scheme, the private shuttle operator would handle NASA's current role of overseeing safety and technical requirements. In the fall 2002, the Rand Corporation delivered similar findings on privatizing the shuttle workforce in a follow-up study.[xv]

However, the NASA body responsible for evaluating manned aerospace programs warned that privatization could exacerbate safety risks. In 2002, the ASAP Chair Richard Blomberg told the House Subcommittee on Space and Aeronautics that NASA would have to indemnify any privatized shuttle operator from financial risk and require a technically experienced workforce to assess and regulate that risk. However, Blomberg reported that, "it is difficult to cultivate and maintain this government workforce when all operations have been turned over to the private sector." Blomberg also noted that a departure from the "traditional government/contractor checks and balances" to privatized operation "would increase risk significantly for a time," and would not improve safety from current levels.[xvi]

Direct evidence of contractor failure to perform efficiently came in 1999 with the failure of a series of Mars spacecraft. The failures highlight how NASA contractors and NASA's managerial commitment to FBC traded avoidable risk for lower cost. In September 1999, the $125 million Mars Climate Orbiter crashed into Mars. It was later revealed that contractor Lockheed Martin had used English measurements to calculate trajectory while NASA specified and navigated the craft using metric units. In December the same year, the $165 million Mars Polar Lander crashed into the planet's surface as its braking thrusters failed to fire properly. NASA's internal investigation revealed that no system wide tests had been done on the Mars Polar Lander before launch. Two Deep Probe 2 microprobes accompanying the Polar Lander were also lost without contact and, according to a Mars Independent Assessment Team head Tom Young, simply were "not ready to launch."

Under budget constraints, the renowned Jet Propulsion Laboratory (JPL) and Lockheed Martin tried to perform a mission they did not have the resources. Lockheed Martin significantly understaffed the development of the Polar Lander, Mars Observer and Deep Space 2 hardware, and then increased staffing by 80 percent halfway through the project. After additional engineers and technicians were brought on, Lockheed Martin required them to work in excess of 70 hours a week. Not only did this increase the costs of the spacecraft by $121 million, 44 percent over the original costs, but it also resulted in an overworked and poorly managed staff producing slipshod spacecrafts. Because launch dates were fixed and calculated so that the spacecrafts would rendezvous with Mars, Lockheed Martin rushed to meet their deadlines, while making simple yet critical mistakes.

Though JPL—an academic center under exclusive NASA contract to operate space *probes*—has a unique technical capability, it did not provide the necessary support the missions needed. Lack of review and analysis of risks allowed for consecutive failures. NASA's investigation into the probe failures also noted "competent, but inexperienced, project managers" and inadequately trained navigation personnel at JPL did not catch Lockheed Martin's mistakes. Though Lockheed Martin's Mars Climate Orbiter navigation software used English units rather than the NASA specified metric units, JPL personnel could have saved the spacecraft before it crashed. However, with an understaffed workforce that did not fully understand the Climate Orbiter craft, JPL navigators failed to recognize anomalies caused by the spacecraft's navigation. NASA's mangers also lacked experience to understand the risks and potential for failure involved in planetary space missions. The inadequacy of testing and oversight on construction of Deep Space 2 probes was so severe that NASA does not have insight into why it failed beyond that it was not tested for operations.[xvii]

While NASA did score successful low-cost robotic missions under *FBC,* such as the Mars Pathfinder and the Mars Global Surveyor, the overall results were not successful. NASA contracted an investigation through the Aerospace Corporation to compare the new mission regime to the traditional robotic probe projects. The study found that the failure rate under FBC missions was 44 percent compared to 30 percent for traditional missions. FBC missions were 57 percent more cost-effective than the traditional model. The faster, better, cheaper missions provided an average of 79 instrument months, over three times less than the average 305 instrument months that traditional robotic missions provided. The Aerospace Corporation report concluded that to achieve "faster" and "cheaper", the mission must give up "better" by reducing scope and science return on a "per mission basis."[xviii]

Contractor fault was also cited in a string of unmanned commercial and military space launch vehicle failures in 1998 and 1999. With seven launch failures over two years, launch vehicle builders Boeing, builder of two of the failed rockets, and Lockheed Martin, builder of the remaining five failed launches, faced intense scrutiny. With three of the undelivered payloads being military satellites, the Air Force investigated the cause of the failures. At the risk of losing commercial business, Boeing and Lockheed Martin also conducted their own internal investigations. Beyond the direct technical causes, all the investigations came to similar conclusions: the companies' poor oversight and evaluation and understaffed workforce allowed engineering and workmanship deficiencies. Even the Defense Department contractor responsible for assessing and certifying the operability of defense launch systems, the Aerospace Corporation, cited *its own* reduced workforce and limited resources under a $3.65 million contract.[xix]

Though NASA's recent experience with contractors shows the limits of performing dangerous and difficult work through the private sector, a privatized NASA may be even more detrimental. NASA's core mission is research and development of new technologies in aerospace, expanding human knowledge of airflight, spaceflight and space and earth sciences for the benefit of the public, including the engineering and scientific communities, as well as the private sector. Privatizing NASA would move aerospace and earth and space science research out of the sphere of public goods and into private hands.

As a public good, the data and research that NASA produces from its projects are publicly available. A telling example of private ownership of space research is the privatization of the Landsat remote sensing satellite system. The Carter Administration's 1978 proposed plan to privatize the satellites was realized in 1985 when EOSAT, a joint venture by Hughes and RCA, took over the operation of the system. The Landsat data that was once available to the international science and research community was now EOSAT's proprietary data. The cost of purchasing Landsat data increased from $400 to $4,400 an image, out of the reach of many researchers in the scientific community. After NASA and the National Oceanic and Atmospheric Administration requested relief from high prices, Congress passed and President Bush Sr. signed, the Land Remote Sensing Policy Act of 1992, putting the satellite system back in the government's hands again. The bill acknowledged that privatizing Landsat, a research program that provides essential data, had deleterious effects and is not likely to work in the future.[xx]

Privatization allows for the possibility that profitability and market value, rather than scientific value, will prioritize the scientific and research work that NASA currently does. Even though a privatization scheme can be developed to give the Federal Government some oversight into strategic planning, the Federal Government would be unable to staff a workforce without some operational knowledge. Further, the lack of safety and risk oversight that results from NASA's understaffed civil service workforce, demonstrates how a privatized aerospace venture would be prone to safety issues.

For the purposes of securing funding and winning contracts, contractors have an incentive to aggressively price their service and products. The space launch failures in 1999 point to private sector managers cutting staff and diminishing engineering quality to competitively price their launch services. As NASA's independent investigation into the 1999 Mars spacecraft failures shows, both Lockheed Martin and JPL, the academic contractor, placed concern with cost before success. While Lockheed Martin's proposal was aggressively priced, they were not able to provide an effective product. Instead of relaying risk assessments and concerns to NASA, JPL's communication with NASA "was more one of advocacy for the program and presenting a positive image to the customer (NASA Headquarters)." [xxi]

In recent years, NASA's mission has been defined by budgets, not science. With private sector salaries significantly higher than government's, NASA is losing its ability to attract talented individuals, as ambitious science and engineering are secondary to contracting, privatizing, and cost cutting. While a publicly funded aerospace program can invest in developing projects that have a high scientific value but no immediate profit, private industry's involvement in aerospace is justified by profit first and foremost. Before the decision to launch the doomed *Challenger* in January 1986, shuttle contractor Morton Thiokol's senior managers overruled a contractor engineers concerns for the safety of the launch and gave NASA the go-ahead to launch. The contractor's management chose not to contradict NASA managers who were eager to launch. With the contract up for renewal, Morton Thiokol was eager to please NASA managers.[xxii]

In the coming months, the investigation into the *Columbia* accident will answer where accountability for the critical failure lies. With the majority of the shuttle's functions under the control of one contractor, United Space Alliance is already fac-

ing scrutiny. With a chorus of warnings about the dangers of contracting out a manned space vehicle that offers little room for a safety lapse, presidential administrations, Congressional budget appropriations committees and NASA senior managers that pushed for lower costs over successful operation, may also have to face scrutiny for their decisions that reduced the effectiveness of NASA.

Endnotes

[i] Chun Wei Chao, *The Knowing Organization* (Oxford, 1998), ch. 5. Chao discusses management lapses at NASA and Morton Thiokol, the Thiokol engineers recommendation against the launch of the *Challenger* in cold temperatures and the organization deficiencies in the NASA-contractor relationship that permitted managerial decisions to override engineering concerns.

[ii] Arnold S. Levine, *Managing NASA in the Apollo ERA,* (NASA, 1982).

[iii] Paul Light, Paul Light, *True Size of Government,* Appendix A. Light modeled his estimates on FPDS data by using agency contract purchase information and types of contracts purchased. Because the FPDS system was implemented in 1984, that year is the earliest an estimate can be made for.

[iv] Goldin quoted in Jason Peckenpaugh, "Doing Fewer Projects More Safely," *Government Executive,* August 1, 2001.

[v] *NASA FBC Taskforce Final Report,* March 13, 2000. For data on NASA workforce numbers, see *http://www.hq.nasa.gov/office/codef/workforce/*.

[vi] Aerospace Safety Advisory Panel, *Annual Report for 2001,* March 2002, p 9.

[vii] GAO Report, Space Shuttle Safety: Update on NASA's Progress in Revitalizing The Shuttle Workforce and Making Safety Upgrades, September 6, 2001; Roberta Gross, Inspector General NASA, *Testimony before the Senate Subcommittee on Oversight of Government Management,* 106th Congress May 2, 2000.

[viii] David Walker, GAO Director, *Testimony before House of Representatives Committee on Science Subcommittee on Science and Aerospace,* 107th Congress, July 18, 2002.

[ix] Roberta Gross, Inspector General NASA, *Testimony before the Senate Subcommittee on Oversight of Government Management,* 106th Congress May 2, 2000.

[x] GAO Report, Space Human Capital Challenges, August 15, 2000.

[xi] Space Shuttle Independent Assessment Team, *Report to Associate Administrator—Office of Space Flight,* March 9, 2000.

[xii] Equals Three Communications and Booz Allen Hamilton, *Commercial Market Outreach Plan for the International Space Station,* prepared for NASA, February 2002.

[xiii] *Report of the Space Shuttle Management Independent Review Team* (Kraft Report), NASA, February 1995.

[xiv] Kathy Sawyer, NASA Plans Privatization for Shuttle; Cost-Cutting Will Hurt Safety, Critics Contend, *Washington Post,* June 7, 1995, A1. Jose Garcia, Letter to President Clinton, August 29, 1995.

[xv] Craig Covault, "Shuttle Privatization Raises Safety Issues," *Aviation Week & Space Technology,* December 24, 2001; Craig Covault. "Shuttle Shakeup Eyed for Cost, Safety Goals," *Aviation Week & Space Technology,* September 23, 2002.

[xvi] Richard Blomberg, Former Chair Aerospace Safety Advisory Panel, *Testimony before the House Subcommittee on Space and Aeronautics,* 107th Congress, April 18, 2002.

[xvii] *Mars Independent Assessment Team Report,* NASA, March 2000; Tom Young, MPIAT Chairman, *Testimony before House Science Committee,* 107th Congress, March 14, 2000.

[xviii] Beth Dickey, Midcourse Correction, *Government Executive,* September 1, 2000. Michael A. Dornheim "Aerospace Corp. Study Shows Limits of Faster-Better-Cheaper," *Aviation Week & Space Technology,* June 12, 2000; Todd Mosher, Robert Bitten, *et al.,* "Evaluating Small Satellites: Is the Risk Worth It? [Aerospace Corporation Report]" presented at AIAA/USU Conference on Small Satellites, August 1999.

[xix] Frank Sietzen, Launch Failures and Recovery Shape 1999's Space Competition, Space.com, posted December 28, 1999; Pete Aldridge, Aerospace Corporation President, Testimony before House Permanent Select Committee on Intelligence, 106th Congress, July 15, 1999.

[xx] National Research Council, Bits of Power: Issues in Global Access to Scientific Data (National Academy: 1997).

[xxi] *Mars Independent Assessment Team Report,* NASA, March 2000.

[xxii] James Colvard, "Savings Can Have a High Price," *Government Executive,* November 1, 1998.

Senator LAUTENBERG. One of the things that they noted in their report was that when a previous administrator—and I can't be delicate here, and it's not in criticism; it's just the information that I looked at this—Daniel Goldin, NASA's Administrator from 1992 to 2001, appointed and directed to make the cut on NASA's budget and to bring fiscal discipline of the business world to the Nation's premier science organization. The agency was then put under a management plan called FBC, "faster, better, cheaper." And I wonder if you'd make a comment about the availability of resources. Did the 1,700 NASA employees have the capacity—and I mentioned this in my comments earlier—to supervise 18,000 contractor

workers? Was there any failure, in your view, that lay heavily at the doorstep of the contractors to provide the kinds of service that might have averted this catastrophe?

Admiral GEHMAN. Thank you, Senator. The Board found—and we looked at this extraordinarily hard. We interviewed hundreds of people. We walked the shop floors of all the centers all over the country where components are made. And we did not find cases where the contractors were taking shortcuts or were cheating or weren't doing their job well. We didn't find any cases like that.

The Board did find, however—and it's in our report—that the management level—that is, the vertical level—that the program has decided to contract to seemed to us to be a little too high. By that, I mean it appeared to us that they were contracting out management functions. They were almost to the point where they were contracting out government functions. And it appeared to us that we didn't find anything wrong. I mean, we didn't find anybody doing anything wrong in that case. But what we found was—then was that when the Government had to make a decision, they no longer had the technical expertise, because the function that they were supposed to be supervising was being done by a contractor. And if you look at the mission management team decisionmaking, you see them consulting people that are experts on whether or not this is a problem. And they're all contractors. And there doesn't seem to be a government person who has the technical knowledge anymore, because they contracted it all out.

So we didn't find any wrongdoing.

Senator LAUTENBERG. I understand.

Admiral GEHMAN. But we did find that perhaps, because so many of the oversight functions were being done by contractors, the expertise goes with the function, we found that the U.S. Government seemed to be shortchanged.

Senator LAUTENBERG. So if there isn't blame—and I understand very clearly what you said—then structure certainly was one of the problems. And I assume, therefore, it's a continuing, or might be a continuing, problem.

The question is whether or not we're prepared to devote the resources to building this organization's capacity to the point that it needs to go on these relatively dangerous missions. We know they're dangerous, and we try our best to protect everybody involved with the program. But are there enough resources? Senator McCain's question about what earmarks do. Well, it robs the program of its appropriate funds to get this job done.

Mr. O'Keefe, what do you think about the resource on this?

Mr. O'KEEFE. Again, it is a very subjective matter, and it is one that——

Senator LAUTENBERG. That's why we hired you.

Mr. O'KEEFE. Yes, sir.

Senator LAUTENBERG. To be subjective.

Mr. O'KEEFE. I fully understand. And my judgment on it is that we have the resources necessary to continue operations in a way that is responsible. The points that Admiral Gehman has raised, I think, has been echoed in a Congressional Budget Office report released this last month. If you'd permit me, Mr. Chairman, I'll submit it for the record, that compares this effort and the resources

and what they refer to as "technologically complex tasks" performed similarly at other agencies and departments across the Federal Government, and find no remarkable distinctions in that regard.

Having said that, the depth of this investigation is deeper than any I have ever been involved in, in my public-service time. And as a consequence, the observations of the Board and the findings of the Board are going to inform us as we go through the examination of the spaceflight operations contract, which comes up for renewal in a year, in order to figure out exactly how we change that alteration, based on the findings, recommendations, and basic views expressed in this report. There's a lot to be learned from that. And while the surface coverage, even from CBO, says "not a lot of comparability between other major systems integration programs," that's not good enough, as far as we're concerned, because the findings of this Board are fact, and we intend to run that to ground to find out how we alter the contractual arrangements, as well as our own conduct, in order to do this stronger and a better way.

Senator LAUTENBERG. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Hutchison?

Senator HUTCHISON. Thank you, Mr. Chairman.

Mr. O'Keefe, were you ever advised or aware, during the *Columbia* mission, that there was a serious problem, or any problem, from the foam strike on liftoff?

Mr. O'KEEFE. No.

Senator HUTCHISON. I'd like to pursue the issue of resources again. Mr. O'Keefe, you had a scientific advisory board that you asked to determine what the resources of NASA should cover, What should be the mission? You got the report back. I would ask you if you think you have the resources to implement that report and establish a vision that not only is scientifically viable, but that the American people can see the necessity to continue?

Mr. O'KEEFE. Yes, ma'am. The very specific review that we asked, and I think you're referring to, is the scientific prioritization to be conducted aboard the International Space Station. That was conducted last summer and early fall. We have, in fact, assessed that. The prioritization is the scientific objective agenda that we will pursue on International Space Station, and the funds necessary to conduct that activity is contained in the President's budget that's before the Congress pending now to pursue that for Fiscal Year 2004 through 2008 as a projection. So that clearly is our intent. We're going to follow that prioritization. That's what the findings of that scientific group was, representing all the disciplines of what could be conducted on an International Space Station, and proceed from there.

To the larger question you posed, though, I think the issue that we've tried to codify and is to codify, and it's part of this year's strategic plan that was released along with the budget, as well, is an effort to be very selective about the areas we intend to pursue and apply those resources as extensively as need be in order to do an extraordinary job in those areas. And then for those areas that don't fit within the category of our three primary mission areas,

that we simply not attempt to do them passingly, but just elect not do them at all and, instead, be very selective about what we do. And I think the budget and the strategy that's before you is our attempt to try to pursue that.

Certainly things changed on the 1st of February, and that's what we need to assess and go back and continue to re-look this relative to the Board's findings and the approach that we intend to take.

Senator HUTCHISON. So, if I could summarize, you think that you have set the priorities and you have the resources necessary to accomplish those top priorities and leave the ones at the bottom by the wayside.

Mr. O'KEEFE. In the scientific objectives, the answer is yes. Again, in terms of our performance of those activities, we're going to be guided by other additional views that the Board may have found here as we go through this to upgrade, update, and improve this approach toward it. But in terms of the science priorities, I think you're exactly right. That effort, a year ago, was the first time we'd ever had a prioritization set that began with the number one and moved progressively through two, three, four, and five. Prior to that, everything was the number-one priority, which, therefore, meant nothing was a priority.

Senator HUTCHISON. I'd like to ask Admiral Gehman. It's clear from your report that there was insufficient resource and that NASA was stretched too thin to achieve its multiple goals. Do you believe that the agency is more budget-driven than mission-driven? In the past. Not going forward, obviously, because we're indicating that there is going to be a change. But do you think it was too budget-driven rather than mission-driven?

Admiral GEHMAN. We believe that the budgets had a lot to do with what happened, with how the management system morphed over the years. And we believe that budgets are one of the constraints on the program. Yes, ma'am.

For example, I was just looking through the report. I was going to try and find it to quote the page to you—normally, I'm like a Bible preacher; I can quote the page that everything is—and I couldn't find it. There's a little sidebar in there which talks about the shuttle upgrade program. The shuttle upgrade program is essentially unfunded. There's a recommendation in here that if you're going to fly this shuttle beyond about 2010, you should completely requalify or recertify the shuttle. That would be a very expensive proposition. Not funded.

We suggest that we need to reestablish the independent technical review authority or reestablish the position of engineers as being independent from the program so engineers can do engineering work independent from the program. And then when you ask for an engineering program—an engineering evaluation, or an engineering decision, you're getting an evaluation from people who don't care anything about the schedule, for example, or the need to make a launch. That requires a couple of hundred people or a couple of thousand people to be funded from someplace, which is currently not funded, because now everything is charged against one of the programs.

So budgets are a big issue. Yes, ma'am.

Senator HUTCHISON. Let me just ask Administrator O'Keefe, in my last couple of seconds. He's talked about the upgrading of the shuttles and the recertification of shuttles, which you have said you're committed to doing, and we also have the new space orbital vehicle that will replace the shuttle. And I would like to ask you if you think—you've said you have the resources to do your high priorities. Have you taken into account the upgrading of the shuttles? And do you have any intention of speeding up the process of the space orbital vehicle that would replace the shuttles?

Mr. O'KEEFE. Yes, ma'am. Two out of three of those. Again, our discussion a moment ago was on the science priorities. But, as it pertains to the three specific items he's mentioned, again, those now are findings, and, therefore, they're treated as fact. Out of the three issues, two of them there are resources set aside. Whether they're sufficient or not is something we've got to evaluate.

For the upgrading of the shuttle, there is a Service Life Extension Program (SLEP) budget line item that's in the budget the President presented to the Congress on February 3. We have to assess exactly what those upgrades are that need to comply specifically with these findings. Whether that comports exactly or whether additional resources are necessary is something that time will tell.

In the second area, in terms of the independent technical authority, Admiral Gehman is exactly right. Whether that takes 200 or 2,000 additional engineers—don't know yet; we're going to have to assess all those options. Indeed, he's right. That's not something we anticipated. That's not something that's contained in this budget, but we intend to do it and will assess what those resource requirements are as we work our way through this.

So the approach would—and as far as the orbital space plane is concerned, there is an additional amount in—there is amounts in the budget before Congress now that was proposed for 2004. The initial funding was——

Senator HUTCHISON. Five hundred——

Mr. O'KEEFE.—agreed to by the Congress as part of the President's amendment, in November of last year, to last year's budget.

Senator HUTCHISON. It's not enough to increase the——

Mr. O'KEEFE. That's exactly right. And I was just about to say that. You're exactly right. The issue of accelerating its delivery is something we need to look at; and the issue is not so much of how much more it will cost, but how much more resources you need earlier in order to achieve that. And that's something we've really got to assess now and make a determination of whether that is in the best interest overall, to pursue that particular approach. But we're working that diligently and have got some answers on what it would take to accelerate this for an earlier delivery of whatever ultimate design would come out of this competitive effort that we're pursuing right now.

Senator HUTCHISON. Thank you, Mr. Chairman.

Mr. O'KEEFE. Thank you, Senator.

The CHAIRMAN. Senator Wyden?

Mr. O'KEEFE. Appreciate it very much.

Senator WYDEN. Thank you, Mr. Chairman.

Let me begin, Administrator O'Keefe, with this question of my sense that you really can't define NASA's mission now without getting on top of the question of manned spaceflight. And I think we're about to start a whole array of commissions and studies and the like. And I would like to ask you whether you could furnish us, within 90 days, or, at most, 6 months, a solid cost-benefit analysis with respect to manned spaceflight. Because I think that's what the Congress really needs. And I know that what I get asked all the time—and certainly there are a lot of critics that say, "Look, they give the bulk of the money to manned programs, but most of the research seems to come from areas that aren't manned." What's your reaction to the proposal I made this morning that you give this Committee a solid cost-benefit analysis on manned spaceflight within 90 days, or, at most, 6 months?

Mr. O'KEEFE. It's a very intriguing idea. I'll give it my best shot. I think that's a very thoughtful way to go about approaching it, and I'll do my very best to provide such a document and an analysis that would demonstrate that. That's a step forward, I think, in proving this.

Two things, though, to observe, as well, though, that—just to be clear on the facts. A third of the budget is really dedicated toward spaceflight activities, of which 25 percent is shuttle, additional amounts are for International Space Station. And then the other two thirds is toward earth science, space science, all the things that are not specifically related to spaceflight activities. So it already is skewed heavily toward activities by a factor of roughly two to one, the kinds of functions that are performed by robotic and distant means. So that's an approach.

The other thing we've got to really assess here—and, again, in pursuit, I think, earnestly to answer the question, the very thoughtful proposal you've put forward, on how to conduct such an analysis—we've got to find some way to factor in what is the cognitive skills that human beings bring to the occasion in these cases. There are some things you simply can't do without a human intervention. And we've got to be selective in the cases in which we expose humans to those risks. And that's essentially what I think you're posing, and it's a very interesting way to go about doing it, and I'll give it my best shot, Senator.

Senator WYDEN. Mr. Chairman, I would just like to follow up with you and Senator Hollings. I've made the proposal, but obviously I'd very much like to do it within the bipartisan approach you've followed in this Committee.

But, to me, that is the bottom line. We have got to get a cost-benefit analysis with respect to what is done in the manned versus unmanned area. And I'll be following that up and look forward to talking to my colleagues about it.

The second question, Admiral Gehman, if I might, involves the compliance issue. I think Senator Hollings touched on this. I mean, the whole history here is tragedy and recommendations made, and then somehow they don't get followed. I'd like your recommendations with respect to how it could be different this time, and to bring about compliance. I mean, for example, I mean, just on a kind of basic level, I mean, we could ask Administrator O'Keefe to come on in here every 90 days and basically say, "Look, this is

what we've done in the last, you know, 90 days." I want to give you a crack at how you'd approach it.

But what I think you want to do, and the dedicated people who staffed this effort want to do, is make sure we're not sitting here in the face of another tragedy. And your thoughts with respect on how to make sure that there's compliance this time, I think, would be another area I'm interested in.

Admiral GEHMAN. Thank you, Senator.

As I indicated in my opening remarks, I agree with your concern, and, as I said in our opening remarks, I think we owe it to the memory of the seven heroes who died to make sure that we do everything we can to prevent this accident from happening again.

In the history of NASA, which we studied very carefully and documented in our report, indicates that NASA, like any other big bureaucracy, responds to the forces that are acting on it. And, unfortunately, over a period of a long period of time, budget, schedule, and cost forces became very important to NASA and they started to affect the program.

The question about how to prevent this from happening again is a very intriguing one. The Board has spent some time scratching their heads about it. We have a couple of examples that have worked well in the past. In the case of the *Challenger* accident, you may recall that the Rogers Commission required that NASA redesign the solid rocket booster joints and O-rings. It wasn't just the O-rings. It was the whole joint. And they also recommended that an oversight committee be established to supervise that, a non-NASA oversight committee. And that oversight committee was in existence for almost 3 years. And they disapproved the first couple of NASA redesign efforts.

You could appoint some kind of a panel or a committee to advise the Congress as to whether or not these management steps have been taken and whether or not they're really working and all that sort of stuff. There is a precedent for that.

I think the Members of this Committee are very much aware that there is a congressionally appointed or congressionally created oversight panel already in existence, called the Aerospace Safety Advisory Panel (ASAP). You might want to assign them with some duties and responsibilities, maybe reformat them, the membership to get at the issues that you're concerned about.

Senator WYDEN. Admiral, if I might—because I know I'm just about to run out of time, and I want your opinion in one other area—the technical engineering authority that you have talked about strikes me as a way to bring about some of the independence and oversight that's important. I would like to hear your thoughts on, sort of, the nuts and bolts of how that would work, and also yours, Administrator O'Keefe, whether you accept the recommendation, and, in effect, how something like this would work.

I mean, the first thing that strikes me is, if NASA puts up the money for it, then you say to yourself, how does that facilitate the kind of independence that you're talking about? But given the fact that you put great weight on this technical engineering authority, tell us how you think it would work. And I'd like both of your reactions. I know my light is on, but I'd like the reaction of both you gentlemen on that.

Admiral GEHMAN. Senator, thank you for that question. That question probably gets to the most important recommendation, and probably the core of our report, and that is that we have found that—over the years, that a legitimate system of checks and balances has been lost in NASA in which there are independent and resourced and robust agencies that kind of check up on each other, within NASA. The Board does not feel that we need to create another entity or an anti-NASA or something like that. But what has happened is, is this independent and robust system of checks and balances has been lost. And it's been lost in the name of efficiency and effectiveness.

And the manifestations of that are really what our report is all about. All the e-mails that didn't get acted on and the inability of engineers to affect things and the overwhelming power of informal chains of command by people in the program and things like, all those things are fixed if you create an engineering world in which engineers can have a robust and honest difference of opinion and you don't do management by view graphs. You use technical papers instead of view graphs and overheads and all those bad things we talked about.

What this organization would do, what we think the key ingredient to the success of this scheme is that this organization must, in fact, own a function. By that, I mean, simply creating an organization that sits on the sideline and kibitzes or second-guesses other people is not good enough. Our suggestion is that this organization actually has to own part of the process. And the part of the process we suggest is that they have to own the technical requirements and specifications and all waivers to them. Now, that implies that they have to understand those technical requirements and specifications. They have to understand why they're there. If anybody wants a waiver to them, they have to understand the rationale for the waiver. And if they don't want to grant the waiver, they have to understand why they're not granting it. So that suggests an engineering enterprise of some size.

It used to be that way a long, long time ago, and that really gets to the core—that really gets to the core of our recommendation, because many—half, 60 percent—of all the ills that we list in our report are immediately fixed because of this enterprise that we recommend. It could be within NASA. We don't necessarily suggest that it has to be outside of NASA.

Mr. O'KEEFE. Sir——

The CHAIRMAN. Senator Brownback?

Mr. O'KEEFE. Oh, I'm sorry.

The CHAIRMAN. Go ahead.

Mr. O'KEEFE. The request was that I respond, as well.

The short answer is, it's a finding, and, therefore it's a fact. It's a recommendation, so, therefore, we're going to comply with it. No further debate on that issue. And what Admiral Gehman and his colleagues on the Board have pointed to is a organizational characteristic that I recognize from my Defense Department experience years ago, particularly the Navy Department experience, which is to have a severability between that institutional force which owns and kind of takes control of specifications and engineering requirements and those that are faced with the program operational con-

siderations of cost and schedule and all the other factors that go into the day-in and day-out kinds of work, and make a very clear severability of those functions. Got the message. That's a clear recommendation. We're going to sort through the options of what is the best approach to do it. And, again, the oversight function that we have put in motion is the Stafford-Covey team of Tom Stafford and Dick Covey, and their 29 or 30 colleagues in all these different disciplines of management, engineering, technical change, organization change, and culture change. All those different experts will then be the judge of whether we have picked the appropriate option to do that. And we will not proceed until such time as we're satisfied that we have selected an option that is not only compliant, but really does follow through on the point that's being raised here.

A final observation is, I concur wholeheartedly on Admiral Gehman's view that there is a statutory board in place right now that the Congress enacted 30 years ago after the Apollo fire, the ASAP, the panel that is focused on these, you know, safety objectives. I think the charge that I'm hearing here and as well as the approach that we need to take is, take that statutory oversight function and reinvigorate it. And we'll have to kind of cogitate on what the right ways are to do that, and certainly would appreciate your support and help in that pursuit, as well.

The CHAIRMAN. Senator Brownback?

Senator BROWNBACK. Thank you, Mr. Chairman, and thank you, gentlemen, for being here today.

Admiral Gehman, in the report it's replete about there's a need for a change of culture. And I think there was one news account that put it accurately, that "Technology is easy. People are difficult." How do you change a culture at an institution without changing the people involved? This seems to me that if you're talking about a cultural issue here, you're not talking about moving boxes or organizational charts around; you're talking about changing whole mentalities and whole attitudes. And that seems to me that you are talking about major wholesale changes in personnel within the NASA system. Is that accurate?

Admiral GEHMAN. Senator, we anguished over this issue for a considerable amount of time, and we also did not—we did not start our investigation with this position. We kind of came to it. And I think that in order to answer your question directly, I have to make it clear that the Board made a clear distinction between management problems and management fixes, and culture. We, in our minds, in our framework, we view these two things as two separate things.

Management can easily be fixed by wiring diagrams and changing rules and regulations and moving people around and changing functions and all that kind of stuff. But the cultural issues are more difficult to get at, much more difficult. We had a little saying that you can fix a management problem by reorganizing, but you can't fix a cultural problem by reorganizing.

Cultural problems are going to have to be driven—bad culture—there's good culture, too, by the way. There's the culture of safety and a culture of honesty and a culture of openness and all those kinds of things, which needs to be reinforced. But bad cultural traits, which we tried to list specifically in our report so we weren't

just waving our arms and beating our breasts here, need to be driven out of the system by active—proactive leadership, and not just leadership from the administrator. He can't do it alone. It's going to take—he can affect probably two levels below him, and then the people below him can affect two levels below them. But it's going to have to take active leadership on behalf of several layers of management in order to get at this problem, and it can't be done in a few days or a few months. And, therefore, we did not make it a return-to-flight thing. It's——

Senator BROWNBACK. Let me—because my time's going to be limited on this—isn't what you're describing, though, that you're going to have to make major personnel changes to change those attitudes, the culture——

Admiral GEHMAN. You can——

Senator BROWNBACK.—up and down through the organization?

Admiral GEHMAN. My experience has been that you can change the behavior of people. You can't change the attitude of people, but you can change their behaviors. I would suggest to Mr. O'Keefe that after trying as hard as he can and repeating the message over and over again, if there's somebody out there who doesn't get it, he has to be replaced.

Senator BROWNBACK. And quickly.

Mr. O'Keefe, in looking at the comprehensive list of recommendations there in chapter 11, it takes me back a little bit. You know, the return-to-flight requirements are extensive. How long do you think those would take to get implemented, and at what cost?

Mr. O'KEEFE. Well, there are 15 very specific recommendations that must be implemented—you're exactly right—prior to any return-to-flight activity. And the answer is, it will occur when we've determined we are fit to fly. Because not just those 15, but anything else we determine that falls into the category of issues which would otherwise compromise successful mission accomplishment is going to have to be accomplished. That bar has to be that much higher. It can't be just those 15.

Senator BROWNBACK. No time-frame then? You can't establish any timeframe? I think you've said that in other interviews. What about the cost?

Mr. O'KEEFE. Again, we have to assess that. Because it really turns on which options we select to implement each of those, particularly those 15, and then all the other recommendations, as well, and the other things we've included in the raise-the-bar, kind of, inputs area. So as we work through, with the Stafford-Covey team, exactly what options we're going to choose, that will then yield a price tag, which will give us a better judgment of exactly what that's going to take.

Senator BROWNBACK. Let me build on that, if I could. And this is, I think, along the line with what Senator Wyden was saying. As you appraise that, there's going to be a cost associated with that. I hope you also look at it and question whether it would be just a better thing to invest in a different technology, if, at some point, we look at—that sooner rather than later, maybe even much sooner, we ground the shuttle and go to a different system, if the cost of implementing this is so high, relative to going to a new technology or a new system. And I would hope that, as you appraise

this, that you look at—this is the amount of time it would take us to get the shuttle back to flight. This is how much it would cost. Are we throwing good money after bad? There's a fair feeling that this is an older technology. It's a complex technology that we may just be at a point—it's time to say shuttle the scuttle—shuttle the scuttle—scuttle the shuttle, and we move on to the next technology. And I hope you will be making that appraisal, rather than just saying, "Well, we're on this line and we're going to go that track."

Mr. O'KEEFE. Yes, sir. As you review the implementation plan, which, again, will be released late this week, early next, and you—that's going to continue to inform the debate of what the scope and magnitude of return to flight's going to require. I'm certain we're going to have a spirited debate, in terms of what exactly that will entail, what it'll cost, what the tradeoffs are. And, again, we intend to be under multiple levels of oversight review in that process.

Senator BROWNBACK. And I can assure you Congress is going to be looking at that question.

Mr. O'KEEFE. Sure.

Senator BROWNBACK. How much time?

Mr. O'KEEFE. Absolutely.

Senator BROWNBACK. What's its cost? Is it just time to go to a new technology? Which, I have to tell you, my leaning is just clearly that that's the way we should be going at this time. There are two major disasters. It's a complex system. It's an older design. This is a 30-year-old design that we're into now. I just can't help but to think that we would do much better—and it may also be a cultural issue when you go at a new technology. We can bring a new team in to design where we're going to next. And that new team will have a different cultural—are you going to be able to shape the attitude of that culture?

I think cultures are critically important. I think it is to the country, and I think it is to institutions. I know it is in my office. And this may be the answer to both the cultural and the technology.

Mr. O'KEEFE. Well, Senator, you've asked me to keep an open mind. I'd just ask that you do the same. As we work our way through this implementation plan, my plea would be let's all keep an open mind in terms of where the options need to go.

Senator BROWNBACK. That's fair enough.

Mr. O'KEEFE. I'd appreciate very much.

Senator BROWNBACK. I hope you also will think about creating this Presidential commission on the future of space exploration. Congress can do that, but that's really an Executive Branch function. And the report noted that we lack a comprehensive and engaging vision. The way I've been looking and seeing is we're stuck mentally in low-space orbit, our thinking is. And I just think you need to get—and I think the country wants to engage in a discussion on what's our vision for space. It's not just NASA. It also involves—I mean, it's discovery and exploration, but it's also commercial and military—to engage that broader discussion of where are we going as a country here. Because I think the country wants to go, but they need that vision that really unites and says, "This risk is worth it. This cost is worth it."

So I hope you'll consider that, a Presidential-level commission to work with establishing that. I know there are difficulties with it,

and there's not a simple answer, but a vision really is a critical thing to unite a country.

Senator BROWNBACK [presiding]. Now, I'll be chairing the hearing the rest of the way out, and who's—Senator Nelson is next up. Sorry about that.

Senator NELSON. Thank you, Mr. Chairman.

Gentlemen, everybody up here wants this program to be successful. And so I'm going to ask some very specific questions.

We have heard the Admiral say—in his excellent report, he has stated "buying power has been reduced 40 percent over the last 10 years." The Admiral has said here today that "money has been squeezed out of the shuttle program." And I'm doing exact quotes from what you said, Admiral. You talked about how the program manager had made trades on the cost; how, looking ahead, that you should separate engineering and safety from the cost and schedule part of the evaluation. And you talked about—all leaders are responsible for the results—the Administrator, the White House, and Congress. You specifically stated that.

So realizing that that has been part of the problem in the past, now I want to ask some very specific questions, Mr. Administrator, as we go forward. This is not partisan. The space program is not partisan. A lot of these questions have been addressed by Senator Hutchison, as well.

I would like to know if you have had discussions—you or any of your immediate people—with the White House—OMB is part of the White House—about the increased expenditures that you're going to come to Congress to ask for.

Mr. O'KEEFE. We are pursuing an interagency discussion on the larger U.S. space exploration objectives. The result of that will yield a very specific answer to your question that will manifest in a request from the President in whatever period of time that takes.

Senator NELSON. It's a request for supplemental that you're talking about.

Mr. O'KEEFE. No, sir. I'm not specifying exactly what form it will take, whether it's an amendment or a supplemental or part of a regular budget request. All that's being vetted now.

Senator NELSON. Well, as the Admiral said, the leadership problems involved everybody in the past. So if we're going to fix this problem, the Congress is going to have to help you and the White House fix the problem. So we're going to need to know how much we're going to have to help you to fix the problem. So can you give us any kind of idea what we're talking about? Because right now decisions are being made in the Appropriations Subcommittee on the 2004 budget.

Mr. O'KEEFE. Indeed. And that process is underway. And as soon as we can get an answer, that's precisely what I have an obligation to come back to you and your colleagues to deliver. Yes, sir.

Senator NELSON. OK. You said you had ongoing discussions. Have you had ongoing discussions in the range of a billion-and-a-half dollars of return-to-flight additional monies?

Mr. O'KEEFE. We have had ongoing discussions. I really don't want to get into what the current state of play is or what the numbers might be, because they really run the gamut. I think, again, as I mentioned in response to Senator Brownback's commentary,

the cost of this is going to depend on which options we choose. There are 29 recommendations, and a whole range of raise-the-bar objectives we're going to have to do. So each of those options is going to have a price tag. The answer to that very specific question will come from the total of how much it takes on the options you select for all 29 of those and every other issue contained in the raise-the-bar inputs that are equally important, in our judgment. So I can't give you an answer to that until we can do that math.

Senator NELSON. Mr. Administrator, you have heard me be very critical of past administrations, both parties, on the way that they use budgetary sleight of hand over the years to get us into the fiscal condition that we are finding, where NASA has not given the specific money directed at safety. You've heard me talk about how the space shuttle budget and the Space Station budget were lumped together back in the 1990s, and then money was transferred around.

Now, it is very much the responsibility of the Congress, as we look at your budgets, to know specifically what has happened. Now, for example, maybe you can share this with us. Of course, as Admiral Gehman said, not only have the budgets been flat with regard to the space shuttle, the budgets have actually—in real buying power, has been a 40 percent drop over 10 years. And, indeed, where I see the difference in what the Administration has requested in 2003 for the space shuttle, roughly $3.2 billion, you would think it was an increase going to the 2004 request of three-point-nine. But, in fact, the institutional account, which includes a lot of the infrastructure that was $1.2 billion in the past is zeroed out. So a number of those institutional costs, including things like infrastructure, are part of that additional funding increase. So where is the increase in your 2004 request that specifically gets at the problem of safety and safety upgrades?

Mr. O'KEEFE. There is a budget line item within the shuttle program for Service Life Extension Program. Of that, we have to identify the prioritization that's underway, that was started before the accident, to begin to work through exactly what is the prioritization of selection of those upgrades and their timely implementation. So the answer to the question is, that's the funding stream that's there. It's not one year. It's in 2004 and each successive year thereafter. There's a continuing funding stream that follows thereafter. As a consequence, this is an enduring program that we intend to put specificity to which upgrade implemented at which time based on which prioritization's set—and, again, informed by a lot of what we will learn as we implement these findings and recommendations.

Senator NELSON. OK.

Senator BROWNBACK. Senator——

Senator NELSON. I see my time is up.

Senator BROWNBACK. Senator Breaux?

Senator BREAUX. Thank you very much, Mr. Chairman. And, once again, thank you, Admiral, for a very fine report. And also thank you, Mr. O'Keefe, for the cooperative effort that you've shown in producing this report.

I'd just ask you, with regard to the Lockheed Martin facility in Michoud, down in New Orleans, what kind of cooperation did you

get, Admiral, in working with them and finding out what they did and everything else?

Admiral GEHMAN. Senator, we got outstanding cooperation at Michoud. And, in particular, we did a lot of work down there, because we and the workforce at Michoud wanted to understand the properties of foam better than had been understood in the past. And, therefore, we asked them how to go about that, and they worked right alongside us in conducting—devising and conducting various experiments.

And certainly the best commentary I can get—I can give you is the very—is the dissection of the already-built bipod ramps that we did. This showed some problems inside those bipod ramps that were unknown beforehand, and it took a considerable amount of courage on those people to help us do that.

Senator BREAUX. Did the separating of the foam from the external fuel tanks become an "acceptable risk" to NASA?

Admiral GEHMAN. The categorization of "separation of foam" changed over the years. It migrated from a very, very serious category to a category that was not so serious, until it absolutely disappeared off the radar scope altogether. And yet it was the same physical event. And that is a—that's a mistake.

Senator BREAUX. It seems to me that we've had this separation of the foam from the very beginning, that we've had separation of foam—the first known incident was back in 1983. The most recent incident, other than this tragic accident, was only 3 months before this final accident. And your report points out that photos exist of foam separating for 65 of the 79 missions, for which we had imaging that was available. And then the regulations of NASA on external tank debris limits said very clearly that "no debris shall emanate from the critical zone of the external tank on the launch pad or during a set, except for such material which may result from normal thermal protection systems reception due to a set heating."

So we've had foam separation from the very beginning, throughout numerous launches, 65 of 75 that we saw pictures of, and as recent as 3 months before this incident, plus a regulation of NASA itself that says no debris separation is acceptable or should be allowed. And yet we were still launching shuttle missions knowing that this was continuing and knowing that we had a regulation that said, "Don't allow this to happen." To me, that seems like a monumental breakdown. Can you comment on that?

Admiral GEHMAN. Yes, sir. And it gets to the core of our recommendation to have an independent technical authority. The adjudication of whether or not the foam anomaly should be treated as a showstopper or not is made by a board, a board of engineers and managers, at the space shuttle program office. And the chairman of that board is the space shuttle program manager. So what we have is a case where the program manager, who has pressures on him for cost and schedule and manifests and lots of other things, having to determine whether or not this anomaly, which is now before the board for adjudication, whether or not he should make a big administrative deal out of this or make a small deal out of it. He knows that if he makes a big deal out of it, it might jeopardize or slow down future launches. He also knows that if he doesn't understand why this is happening, it'll cost a couple of mil-

lion dollars to do some research and development, a couple of million dollars that he doesn't have, to find out why foam is doing this and what are the properties of it and how to fix it. And so this one person, who's got all these pressures on him, is making these decisions, and we found to be not a good system.

Senator BREAUX. I'm not sure how an outside board is going to help you on this particular degree of investigation or supervision, because we already knew it was happening. We have a rule that says "no debris shall separate or shed," and we have numerous instances of launches where this was occurring. It was despite a rule that said, "Don't let it happen." It was happening, and we were continuing to launch vehicles knowing it was happening. An outside board's going to tell us the same thing we already know.

Mr. O'Keefe, was it a matter of cost? I mean, we have a regulation that says it should not happen. It was happening, and we were still launching knowing that it was happening as much as 3 months before this launch. Is the reason that it was allowed to continue a cost reason or was it simply people ignoring the regulations and ignoring what was happening?

Mr. O'KEEFE. I don't discount anything that Admiral Gehman has offered here. Again, I think those are all contributing factors. But I think there are two overriding reasons why this happened.

The first rule, which you cite properly, exactly, very precisely, that was set is viewed in the agency and within the shuttle program as a "goal."

Senator BREAUX. As what?

Mr. O'KEEFE. A goal. Not a requirement, not a hard, fast specification. That's a fool's errand, heading down the road toward saying, "Well, we'd like to achieve this," because that means we regularly rationalize why we would waive something we view as a goal, not as a requirement, as a specification. And that's a big mistake. So we've really got to look back. So that's the first issue, we really have to make that rule as firm as you just described it to have folks understand what is it that's inviolate that you simply cannot transcend, and where are those cases in which there's a desired objective that we have to continue to achieve, and find a way to get there, or else simply define this as a goal that's not achievable.

And the second case is, what we're dealing with here is human nature. It is—like everything else in life, when you see something repetitively, it begins to fuel a rationalization of why that's not a problem.

Senator BREAUX. That's the cultural problem.

Mr. O'KEEFE. Yes, sir. They go hand in hand, but I think they have to be viewed compatibly. That human tendency we shouldn't be surprised to see in engineers when we see it in everyday life.

We all know anytime you walk down a metropolitan street, anytime there is a homeless person sitting inside of a doorway, there is some number of people who are stunned by the fact that people walk by with absolutely no cognizance of the fact that's going on and have ignored it. If anybody came from a South Pacific paradise island and walked down that same street, they'd be aghast at seeing at humanity is being treated and would be amazed by how it is we, as a people, could tolerate that.

And so it's that first occasion in which you see it that raises that interest level. We shouldn't be surprised when engineers act just like the rest of people do. When they see something repetitively, they begin to rationalize and begin to look at things and assume what it is they think they know about it. And in every other instance—and here's the big mistake, and Admiral Gehman and the Board pointed to this very, very clearly—this human nature said, "If nothing happened previously, it probably won't happen again in the future." That's the wrong direction. It ought to go in the opposite approach, which they have said repetitively in this report, which is, "We've got to prove that it's safe, not prove that it's not." And that's a point that really has to be driven home. As a consequence, we really have to take that same mindset and understand that while this is a human nature, human characteristic, that when we see things repetitively, that we take it for granted or begin to make assumptions or whatever else. It simply can't be tolerated here, because the stakes are too high.

Senator BREAUX. Well, we all know what happens when we assume.

Mr. O'KEEFE. Yes, sir. We do it in every discipline. Every single discipline in every walk of life. There are assumptions that are considered to be inviolate, and we've got to go back and question what those assumptions are. That's a real tough order, and it's one that's going to take us a lot of time and discipline.

Senator BROWNBACK. Senator Dorgan?

STATEMENT OF HON. BYRON L. DORGAN,
U.S. SENATOR FROM NORTH DAKOTA

Senator DORGAN. Admiral Gehman and Administrator O'Keefe, thank you for your testimony this morning.

I was thinking, as I was sitting here, having read recently about the December 17, 1903, 59 second flight by the Wright brothers at Kitty Hawk, and in the 100 years since, we have had all manners of tragedy and exhilaration and success. And especially the space program, it seems to me, is the one aspect of going from leaving the ground to walking on the moon, the one aspect of walking on the edge of the envelope of technology and science, and one would expect that there will always be those who suffer the consequences of tragedy in those circumstances.

But these tragedies that have occurred, this one especially, and the investigation you have completed tell us that there are certain things that can and should and must be done to prevent this from happening again. I mean, the fact that we're dealing on the edge of the envelope in science and technology does not in any way excuse tragedies that could have been prevented. And those heroes, as you've described them and as our country understands them to be, and that space—in the space shuttle should expect—should have expected then and certainly the future astronauts should expect everything possible is being done to provide for their safety.

I want to ask you just about two issues quickly. And let me say, first of all, Admiral Gehman, I'm not a scientist or—I don't have the technical ability, perhaps, to have fully digested everything that your report includes, but it seems to me you have done a massively thorough job.

Administrative O'Keefe, you have, I think, been a very stand-up Administrator here in these circumstances. I raised questions immediately about the proposition of whether NASA could create its own investigative board reporting to NASA. Others raised the same questions. You responded immediately by changing the Board's charter, removing references to the requirement that NASA oversee and review the Board's investigation and so on. I think the result of that, Administrator O'Keefe, gives us a report that does have true independence. And I think your working with it the way you have has been admirable, and I appreciate that leadership.

I want to ask you——

Mr. O'KEEFE. Thank you, sir.

Senator DORGAN.—a few things.

Mr. O'KEEFE. Thank you.

Senator DORGAN. One, the requirement of the mission management team meetings every day during a shuttle flight, those—NASA regulations required such meetings every day, and my understanding is, from your report, it occurred—those meetings occurred only five times during the 16-day mission, and that discussions regarding the risks of the foam strike and the need for additional imagery, the request for imagery did not surface at all at these meetings that were held. So, 15 of these, or 16 of these meetings should have been held, I guess, and five of them were held; and at the five that were held, no discussions were developed in those meetings with respect to the request for imagery, despite the fact that beneath all of that these discussions were occurring. Can you describe that,—perhaps both of you describe that for me. Is that part of the culture issue or part of the assumption issue that never came to the attention of those who should have been attending to it?

Admiral GEHMAN. I'll start off by saying that the characterization is correct that you made. They held five MMT meetings in the 16-day flight. They're required to meet every day. We went back to the three previous missions and counted up the number of times the MMT met. And guess what? They don't meet every day. They've been meeting every third day for as long back as we can find records. And this is an example of culture at work.

What happens is, you've got regulations, "You've got to do it this way." Over a period of years and years and years, you kind of atrophy to where you do it this way. You're violating your own rules and regulations, and now you're sending all kinds of informal messages through the system, that it's OK to violate your rules and regulations. And then the top-level managers are doing it, "We don't need to meet every day. We can meet every third day. It's good enough. E-mails are good enough." And we're not sure what e-mails count for. I mean, are e-mails official communications, or not?

And so this is a classic case. So I wouldn't blame the fact that there were only five meetings on this mission as being causative. In other words, that's the way they've been doing it for years, so there's nothing different about it.

Now, we made the point in our report that these meetings are very short, that some of them were 30 minutes long. The longest one was about 50 minutes long. And if they really had met every

day, maybe they would have inquired into some of the more minute details of what was going on, and the subject of imagery might have come up. Pure speculation.

Senator DORGAN. Mr. O'Keefe?

Mr. O'KEEFE. This report very clearly indicates that the rules and regulations that we have promulgated over the years are treated much the same way as stop lights in Naples; they're advisory. That's not tolerable. We cannot have that. We've got to go back and really look at what those operational procedures call for, and put in motion that which we believe. And that's part of the recommendations. That's part of our raise-the-bar input standards that we really have to implement and have a very clear understanding of how those operational rules will be promulgated and followed as we go through this.

Because the intent behind the MMT, I think it's a good one, which is to coordinate views and positions, inputs, and then serve it up for decisionmaking. Well, there was an awful lot of stray voltage, is what this report indicates, of lots of communication going on, but to no particular point, in some cases, or to no particular decisionmaking alternative. That's a failure, really, to understand the purpose of the rules. And over time, I think, as the chairman of the Board observed, as well as all of his members, that, over time, if these things are viewed as advisory, what's the point? Why are they there? And that's something we've really got to take back as a strong indictment of the culture, and we've got to correct it.

Senator DORGAN. And, Administrator O'Keefe, the reason I asked this specific question is the mission management team meetings—I don't know much about this at all, except that my assumption would be that "mission management" means just what it sounds like, managing the entire mission. And the fact that it didn't meet, not only in this shuttle flight, per regulation, every day, but in other shuttle flights, as well, but, more than that, the fact that when it did meet, it did not have the information flowing up to it of questions being raised in the organization about the question of whether they should have additional imagery to determine whether this foam had caused some damage to the wing. I mean, that's an organizational issue, it seems to me, and a structural issue of very significant——

Mr. O'KEEFE. Yes, sir.

Senator DORGAN.—importance to the future of operations of NASA.

Mr. O'KEEFE. It's an important process question that must be resolved. No question.

Senator DORGAN. And I wanted to ask, just briefly, a question about the next-generation launch vehicle. The return-to-flight for the shuttle, one hopes, will occur at some point when we have satisfied all of these issues, and there's much work to be done. But my understanding is that the next-generation launch vehicle is meant to complement rather than replace the shuttle. And as I read the investigative report, what you are saying, Admiral Gehman, is that this shuttle vehicle is yesterday's technology, it needs to be replaced rather than to have some other vehicle complement it at some point. And this gets back, I think, to the question that my colleague, Senator Nelson, was asking, as well. I

mean, all of that costs an enormous amount of money. Replacing this launch vehicle completely will be a significant capital requirement, will it not?

When we go back to return-to-flight with the space shuttle, will you, by that time, have made a decision about what your next-generation launch vehicle will be and whether it's going to fully replace it in a certain time period, or whether you're going to continue to try to complement it as your current plans would indicate?

Mr. O'KEEFE. Yes, sir. No, the short answer is yes, indeed. By the time we return to flight, we really have to have an answer to those questions, and we're in the process right now, very hard, of trying to resolve precisely what the composition of this will be, using as the baseline the integrated space transportation plan that we have presented to the Congress as part of this year's budget and was endorsed last year as part of the President's amendment in November.

I'd ask Admiral Gehman to comment, though, on the characterization of this particular finding, because I read it a little differently. And rather than have us go through mutual interpretations here, let's ask the oracle to render exactly what was the intent behind the words that are used here, in terms of chapter 9 and where we should be going.

Admiral GEHMAN. After we had studied this system in such great detail, the Board felt that we owed it to the public and to the United States and to the Nation to editorialize a little bit on the safety and the longevity and the life span of the shuttle, as we know it.

In chapter 9, we opined that the Board was surprised and disappointed to find ourselves at—here we are at 2003, and we don't even have a replacement vehicle on the drawing boards. I mean, we're still debating. We're having a debate about the replacement vehicle. The Board found that the shuttle is not inherently unsafe. It can be operated for another number of years if the recommendations of this Board are followed through on. But the Board finds that operating it for another 20 years, or something, is beyond our—beyond the scope of our imaginations, and that sometime in the period of something like 10 years from now, if you're going to operate it more than about 10 years, you're going to have to fully recertify and fully requalify the vehicle, which would be extraordinarily expensive.

Senator DORGAN. From what I understand your answer to be, if you were an astronaut and if the recommendations of the Board were followed, you would not have difficulty joining the crew and flying the shuttle——

Admiral GEHMAN. That's absolutely correct.

Senator DORGAN. You would fly it yourself.

Admiral GEHMAN. That's correct.

Senator DORGAN. All right. I expect you won't get the opportunity, unless it's a——

Admiral GEHMAN. I asked.

[Laughter.]

Mr. O'KEEFE. Fortunately, that was not a finding and recommendation which we intend to accept and comply with. So, as

a consequence, this is a debatable point, and I think he wants to head back to his sailboat.

Senator DORGAN [presiding]. Well, this is obviously deadly serious business, and the work you have done has been long and labored, but I think you've accomplished much with it. And I think that the Chairman has done a real service for this Committee and for the Senate in calling this hearing today at this time. And you've done some significant benefit, I think, for this country and its space program in your testimony and in the work you've done prior to it.

Let me just make one final comment and say that I come from North Dakota. I mean, I don't have a space launch pad in the middle of my state, as do Florida and Texas. But I really believe a society that stops exploring stops progressing. I think space exploration has been very important for this country. I want it to succeed. I want it to continue. I think the benefits are very substantial. But it will only succeed and continue if we understand that these tragedies require an enormous amount of work to understand what has happened and prevent it from happening again. Again, we're operating on the edge of the envelope of knowledge here, and some wonderful men and women—heroes, in my judgment—one of whom served with us here in the Senate, Senator Glenn, have been the pioneers in space travel. But I really think we're just at the beginning phase of understanding what the rest of our universe is and how to explore it and the benefits it can provide for us.

So let me, again, thank the Chairman, who had to depart. And Senator Nelson has a final question, and then he will close out the hearing.

Senator Nelson?

Mr. O'KEEFE. Senator, if I could just quickly observe——

Senator DORGAN. Yes.

Mr. O'KEEFE.—on your point, I think you've got it spot-on. I mean, we are really in the equivalency here in space exploration of the age of sail. We have really just gotten started. As humankind has pursued this approach, it is very early in this process. And we've got a long way to go. And the expanse to what we could conquer by this really is just unimaginable in its expanse. And so, as a consequence, I think exactly the way you've characterized this is precisely the way I look at it. This is a daunting challenge, and we're at the very beginning of it. It's a tremendous responsibility, and it's one we take very seriously.

Senator DORGAN. Thank you very much.

Senator Nelson?

Mr. O'KEEFE. Thank you, sir.

Senator NELSON [presiding]. Senator Dorgan, I want to pick up on your question about the next-generation vehicle.

Mr. O'Keefe, you and I have talked many times, both privately and publicly, about how you could get some more money with regard to this next-generation vehicle. And one of the things we have discussed is that other agencies of the Federal Government could share in the expense of developing the technologies, that NASA would oversee the research and development, because those technologies would be of value to other agencies. Would you share with the Committee what is happening there, from a financial perspective in the future?

Mr. O'KEEFE. Well, the current ongoing effort we have underway—for example, on the X–37 technology demonstrator—is a good example of the kind of arrangement in which there are advantages that may be derived for multiple purposes. And so, as a consequence, NASA and the Defense Department—Air Force, particularly—are really examining exactly where that approach is going. We are financing with them the overall expense related to the launch and test phase of that particular technology demonstrator.

The orbital space plane, which is, again, the follow-on effort that Senator Dorgan referred to—we are right now in the process of inviting the industry to respond to the requirements, which, again, can be summarized in one page. This is what we want it to do, and here are the capabilities we need. And there are a number of different technologies that are accented, if you will, that may have great application, or the Defense Department may go in on that, and we are engaging in discussions with them.

But at this present time, on the orbital space plane, the objective is that we get about the process of finding a complementary asset that is crew-transfer vehicle in its orientation, that the Board observed in chapter 9, is the kind of thing we need to do, as expeditiously as possible. And we're now in the process of trying to figure out, How do you define "expeditious"? How quickly can it be done? What's it going to look like? And the industry is actively playing in that and working through that particular contractual effort that's being engaged right now. So we should have an answer to that in very short order.

Senator NELSON. Do you expect that, in a net outflow of dollars from NASA, that that will require additional money to be budgeted in NASA?

Mr. O'KEEFE. It heavily depends on how soon we want to see delivery of the asset. As I mentioned in response to Senator Hutchison's comment, the amount that we have included in the NASA budget now before Congress in the 5-year stream, certainly is a resource allocation for an orbital space plane. It will not be sufficient to cover any delivery date that we may desire. To the extent we want to accelerate that, it isn't going to require more in aggregate. It may require more up front. And that's part of what we've got to sort through now. But, again, very thoughtful questions, commentary, and direction that you've given us at previous hearings, and along with other of your colleagues, prompted us to go back and look at that trade study, figure out what it's going to take in order to accelerate this. What are the approaches we would use in that regard? And in no instance have we made the requirements negotiable. We've made those the fixed constant, and everything else around it the variables that we may want to consider, in terms of accelerating its delivery or what other approach you'd use for crew transfer versus crew rescue and the like.

Senator NELSON. And what timeframe, so that we can be expecting it, would you expect to come to the Congress for that kind of request?

Mr. O'KEEFE. To the extent that a request is required, it will be at the point in which the President determines that that's necessary, and that's exactly when it will be delivered.

Senator NELSON. And is your answer the same, then, with regard to the additional expenses that will be required for the return to flight?

Mr. O'KEEFE. Again, those are more dependent. I've got to serve up to, I think, all—within our administration, a clear understanding of the options we choose for the 29 recommendations and the raise-the-bar inputs, that are going to be equally important, and make a determination of how much we need in order to implement the options we've chosen. And that is going to—again, be a fulsome debate within the administration, and we're in the midst of that now.

Senator NELSON. All right. I will just merely close out my comments and the considerable fine hearing that we've had and thank you both by saying you've read the Gehman report. The Gehman report said that the cost-cutting in the past has been part of the problem. That's what I said I was pleasantly surprised in seeing in the report, because I didn't anticipate that Admiral Gehman's Board was going to address cost. It is part of the problem, and they have identified it. And the long and short of it is, over four administrations—and this is bipartisan, both parties—that NASA has been, to use my word, "starved" of funds. And it has always been that Office of Management and the Budget that has said "nyet" to NASA.

I think everybody, including the Members of this Committee, that want, as Senator Dorgan so eloquently said, to see our space program continue to be robust and fulfill that desire of this Nation to explore, needs to know that you're going to be in there fighting in the internal fights in the administration, with OMB, and the White House, to make sure that the monies are there for NASA.

Mr. O'KEEFE. Yes, sir.

Senator NELSON. That answer is good enough for me.

[Laughter.]

Mr. O'KEEFE. Thank you, sir.

Senator NELSON. Admiral Gehman, again, you've done a great service to the country, an enormous service. We thank you from the bottom of our hearts.

No other questions from the Committee. The Committee is adjourned.

[Whereupon, at 11:52 a.m., the hearing was adjourned.]

A P P E N D I X

CONGRESSIONAL BUDGET OFFICE—U.S. CONGRESS
Washington, DC, July 29, 2003

Hon. TED STEVENS,
Chairman,
Committee on Appropriations,
United States Senate,
Washington, DC.

Dear Mr. Chairman:

In response to your request, the Congressional Budget Office (CBO) has reviewed the past and current use of contractors by the National Aeronautics and Space Administration (NASA) to operate and maintain the Space Shuttle. CBO has also examined other cases in which the United States government uses contractors to perform technologically complex activities. CBO's examination focuses on selected activities that it judges to be of interest based on their content. While informative, these examples do not constitute a comprehensive review of technologically complex activities conducted by the government. Nor has CBO audited the performance of the government sponsors or contractors involved in these activities.

The activities CBO examines span a broad range and include maintaining and upgrading weapons systems, designing and producing weapon systems, operating and maintaining government nuclear facilities, and designing nuclear weapons. The nature of the work contractors perform varies among these activities. In some cases contractors are designing and producing complete multi-element systems; in other cases the contractors maintain or install upgrades to specific government-owned hardware or operate facilities for the government. How the government defines the work that the contractors perform also varies—in some cases the government provides a set of detailed, comprehensive specifications; in others the government uses top-level performance measures, leaving some or many details to be defined by the contractors. The cost of the work varies from annual expenditures of tens of millions of dollars to billions of dollars. The contracts used are in some cases sole-source and in others competitively awarded; some contracts are cost plus fee, and some are firm-fixed price. The size of the government workforce performing oversight of the contractors varies from less than one hundred to more than a thousand people, and how that oversight is conducted also varies. Thus, many of the elements of the examples CBO has examined differ from the ways NASA uses contractors to operate the Shuttle. Nonetheless, all of the examples considered by CBO involve the government's use of contractors to perform demanding, technologically complex tasks, a situation that is not unique to NASA.

The attachment to this letter describes CBO's review, which was prepared by Adebayo Adedeji, David Arthur, Eric Labs, Fran Lussier, and Robie Samanta-Roy of CBO's National Security Division. CBO's staff point of contact for this effort is J. Michael Gilmore.

Sincerely,

DOUGLAS HOLTZ-EAKIN,
Director.

Attachment

cc: Honorable Robert Byrd
Ranking Member

ATTACHMENT

NASA'S SPACE FLIGHT OPERATIONS CONTRACT AND OTHER TECHNOLOGICALLY COMPLEX GOVERNMENT ACTIVITIES CONDUCTED BY CONTRACTORS

Congress of the United States—Congressional Budget Office—July 29, 2003

Contents

Summary and Introduction

The space shuttle, formally known as the Space Transportation System (STS), was developed during the 1970s. The first operational shuttle, *Columbia,* was delivered to the National Aeronautics and Space Administration (NASA) in 1979 and first flew in 1981. The shuttle consists of a reusable orbiter manned vehicle, two reusable solid rocket boosters (SRBs), and an expendable external tank that holds the propellants used by the orbiter's three space shuttle main engines (SSMEs) during launch. The shuttle fleet initially consisted of four orbiter vehicles, and NASA initially planned for the STS to fly up to 60 missions per year; however, at most, it has flown only eight missions annually. In 1986, the *Challenger* exploded on its ascent to orbit, and subsequently, the Congress authorized funds for a replacement vehicle. On February 1, 2003, the *Columbia* disintegrated as it reentered Earth's atmosphere. Currently, there are three remaining orbiters in the fleet—*Atlantis, Discovery,* and *Endeavour*—which have about 75 percent of their design life remaining, based on a goal of 100 missions per orbiter.

The space shuttle program continues to be one of the most significant individual portions of NASA's budget. In the President's budget for 2004, the space shuttle accounted for about 26 percent of NASA's total proposed funding.

In 1995, NASA began planning to consolidate the numerous individual contracts it was using to operate the shuttle into a single contract let to a single contractor. In 1997, NASA initiated the first phase of that consolidation by contracting with United Space Alliance (USA), a limited liability company owned jointly by Boeing and Lockheed Martin.[1] Under the Space Flight Operations Contract (SFOC), USA was to perform some—but not all—of the tasks associated with shuttle operations. Not all of the originally planned consolidation has occurred, although additional ac-

[1] Limited liability companies (LLCs) have characteristics of both regular corporations and partnerships. Like the stockholders of regular corporations, the owners of LLCs are not personally liable for the debts and liabilities of the organization. However, an LLC can be taxed as a pass-through entity, like a partnership, so there is no corporate tax on its net income. The profits of the LLC are automatically included in the owners' income for tax purposes.

tivities were subsequently incorporated under the SFOC in Phase II, which began in 1998. In particular, the propulsion elements, such as the external tank, SSMEs, and propellant portions of the SRBs, have not been incorporated under the contract. NASA still uses multiple contractors, albeit a lesser number than it used originally, to operate and maintain the shuttle.

At the request of the Chairman of the Senate Appropriations Committee, the Congressional Budget Office (CBO) has reviewed NASA's past and current use of contractors to operate the shuttle. CBO's review also describes other cases in which the U.S. Government uses contractors to undertake technologically complex endeavors like the shuttle's operation and maintenance (see Table 1). CBO's examination focuses on selected illustrative activities that it judges to be of interest on the basis of their content. Although selected to be informative, the examples do not constitute a comprehensive review of the government's technologically complex activities. Nor has CBO audited the performance of the associated contractors or government agencies.

The activities that CBO examined span a broad range and include maintaining, upgrading, designing, and producing weapon systems; operating and maintaining the government's nuclear facilities; and designing nuclear weapons. The type of work that contractors perform varies among those activities. For example, in some cases, the contractors may design and produce complete multielement systems; in other cases, they may maintain or install upgrades to specific government-owned hardware or operate government facilities.

How the government defines the work that the contractors perform also varies—in some instances, the government may provide a set of detailed, comprehensive specifications; in others, it may use less specific performance measures, leaving some or many of the details to be defined by the contractors. The cost of the work ranges from annual expenditures of tens of millions of dollars to billions. The contracts used are sometimes sole-source contracts and sometimes competitively awarded; some are of the cost-plus-fee type, and others feature firm fixed prices.

Table 1.—Examples of Selected Technologically Complex Government Activities Conducted by Contractors

Activity	Government Department
Coast Guard Deepwater Project	Department of Homeland Security
Evolved Expendable Launch Vehicle Program	Department of the Air Force
Future Combat System	Department of the Army
Lawrence Livermore National Laboratory	Department of Energy
Logistics Support for the B–2 Bomber	Department of the Air Force
National Missile Defense—National Team	Department of Defense
Refueling/Overhauls for Aircraft Carriers	Department of the Navy
Savannah River Site Program	Department of Energy
Trident Ballistic Missile Submarine Conversions to Perform Conventional Missions	Department of the Navy

Source: Congressional Budget Office.

The size of the government workforce that oversees the contractors for a given activity varies from less than 100 personnel to more than a thousand, and how that oversight is conducted may differ from activity to activity. For example, in some cases, the government may require contractors to prepare and submit reports according to government specifications; in other cases, it may use internal contractor-generated reports.

In sum, many of the features of the activities that CBO has examined differ from the elements that characterize NASA's use of contractors to operate the space shuttle. As is the case with the shuttle's operation, however, all of the examples involve the government's use of contractors to perform demanding, technologically complex tasks, a situation that is not unique to NASA.

History of NASA's Use of Contractors to Operate the Shuttle

As noted earlier, from the early 1980s through 1996, NASA used numerous contracts with individual contractors to operate and maintain the space shuttle. In late 1994, NASA Administrator Daniel Goldin formed an independent team to propose approaches to improve the shuttle's management. The team was led by Christopher Kraft, the flight director during the early Mercury and Gemini missions; its membership was drawn from the aerospace industry and former NASA leaders. NASA stated that the panel's objective, set within the context of flat NASA budgets and initiatives to reduce the civil service workforce, was to maintain safety while significantly decreasing total operating costs.

The *Report of the Space Shuttle Management Independent Review,* also known as the Kraft report, was released in February 1995, and its key recommendation was

to place the shuttle's operations under a single prime contractor. In addition, the review team recommended that NASA reduce its involvement in and oversight of the operation of the space shuttle, transferring responsibility for daily operations to the contractor; and that various elements of the shuttle program, such as its processing before flight and its flight operations, be consolidated and reduced, along with the minimizing of NASA-contractor interaction. The Kraft report stated (p. 8): "Many inefficiencies and difficulties in the current Shuttle Program can be attributed to the diffuse and fragmented NASA and contractor structure. Numerous contractors exist supporting various program elements, resulting in ambiguous lines of communication and diffused responsibility. This type of fragmented structure and contract management provides little promise for significant cost reductions."

In September 1995, NASA held a competitive bidder's conference for the Space Flight Operations Contract, which was attended by Boeing, McDonnell Douglas, Rockwell/Lockheed Martin/United Space Alliance, and a small business (BAMSI International). USA was to be a limited liability company, with ownership split equally between Rockwell and Lockheed Martin—which at the time together accounted for approximately 69 percent of the dollar value of all shuttle-related prime contracts. In November 1995, the NASA administrator submitted a so-called Determination and Findings to the Congress, which concluded that it was in the public interest to award a sole-source contract for shuttle operations to USA. NASA awarded the SFOC effective October 1, 1996, and a total of 9,400 employees of Rockwell, Lockheed Martin, Unisys, and Allied Signal became employees of USA. In December 1996, Boeing acquired Rockwell and hence joined Lockheed Martin as an owner of USA.

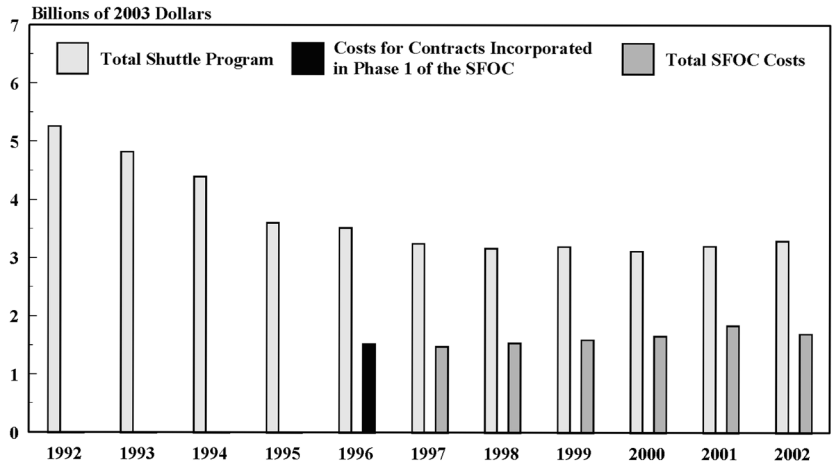
Prior to initiation of the SFOC, NASA had taken steps to make the shuttle program more efficient. Over a period of five years starting in 1990, operational maintenance requirements and specifications decreased from 11,000 to 8,000, while the number of hours of labor devoted to processing each vehicle for a mission was cut from about 1 million to 750,000. Operating costs were reduced by about 25 percent. The majority of the reductions in NASA's overall shuttle workforce and budgets since 1992 occurred before the SFOC was initiated (see Figure 1 and Table 2).

SFOC costs have varied over time because of changes in its content (for example, the incorporation of additional activities under Phase II) and variations in annual launch rates. The reductions in the space shuttle's budget and workforce that occurred from 1990 to 1995 are due in part to changes that NASA made in its requirements for inspecting the shuttle during processing. Before 1989, preparing the shuttle for a launch required contractor and government personnel to execute about 44,000 government mandatory inspection points (GMIPs) and 325,000 designated inspection points (DIPs). GMIPs are required by NASA in order for it to accept the work performed by its contractors on the shuttle. DIPs are inspections performed on work that if not accomplished correctly could result in the loss of life, a vehicle, or a mission or in a major schedule delay. Between 1993 and 1995, NASA introduced a "structured surveillance" program in which technicians were allowed to ensure the quality of their own work, primarily for non-single-point failure systems. That approach reduced GMIPs to around 22,000 and DIPs to around 140,000 per launch. During the 1997–1998 period, NASA made a concerted effort to further reduce nonessential inspections, which resulted in a drop in GMIPs to around 8,500.[2] The DIP count, however, remained at 140,000.[3]

[2] After wiring problems were found on *Columbia* in 1999, a few more GMIPs were added.

[3] As an example, before 1997, both NASA and contractor personnel performed postflight inspections of the thermal protection system, although NASA determined which tiles to repair and replace and performed the final preflight inspection. After the reduction in inspections, USA conducted the postflight inspection and determined which tiles to repair and replace. NASA then performed the final preflight inspection. In this case, the contractor performed the same number of inspections, but NASA was able to eliminate one set of inspections.

Figure 1. Annual Budgets for the Space Shuttle



Source: Congressional Budget Office based on data from the National Aeronautics and Space Administration.

Notes: SFOC = Space Flight Operations Contract. About 10 percent of total SFOC costs are for work related to the International Space Station.

This figure does not include salaries for NASA's civil servants or overhead.

The Space Flight Operations Contract

The SFOC (formally known as NAS 9–20000) between NASA and the United Space Alliance, is a cost-plus-fee contract. According to NASA, the SFOC is a"completion form" contract under which the contractor is responsible for performing a specific set of tasks defined in a statement of work that is part of the contract.

The value of the original contract was $6.94 billion and the period of performance was from October 1, 1996, through September 30, 2002, with two two-year options. The first of the two options has been exercised, for a cost of $2.9 billion, and will expire in September 2004. The second option would extend the contract through September 2006. NASA also has two other shorter-term options under consideration that would extend the contract through December 2004 or March 2005. The total value of the contract to date, including shuttle upgrades and other annual authorizations, is $12.8 billion.

Table 2. The Space Shuttle's Workforce, 1992 to 2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
NASA Employees Associated with the shuttle program	4,000	3,800	3,300	3,066	2,650	2,196	1,954	1,777	1,786	1,759	1,724
Associated with the SFOC[a]	n.a.	n.a.	n.a.	n.a.	n.a.	1,604	1,252	1,260	1,251	1,219	1,191
SFOC Contractor Personnel[a]	n.a.	n.a.	n.a.	n.a.	n.a.	12,207	11,989	11,820	12,859	13,478	12,958

Source: Congressional Budget Office based on data provided by the National Aeronautics and Space Administration.

Notes: Not all personnel who work on the shuttle program do so full-time. The numbers of government personnel in the table denote full-time equivalents assigned to the program.

SFOC = Space Flight Operations Contract; n.a. = not available.

[a]The SFOC was initiated in 1997. CBO was unable to obtain comprehensive data on the numbers of NASA civil servants and of contractor personnel associated with overseeing and executing the individual contracts that NASA used to operate the space shuttle before the SFOC's initiation.

United Space Alliance

Under the SFOC, USA has overall responsibility for processing selected shuttle hardware, which includes:

- Performing inspections and modifications of the orbiter,
- Recovering the expended solid rocket boosters,
- Assembling the sections that compose the SRBs,[4]
- Attaching the external tank to the orbiter, and
- Installing the space shuttle main engines within the orbiter.

In addition to processing shuttle hardware, USA is responsible for mission design and planning, astronaut and flight controller training, design and integration of flight software, payload integration, flight operations, launch and recovery operations, vehicle-sustaining engineering, flight crew equipment processing, and operation and maintenance of shuttle-specific facilities such as the Vertical Assembly Building, the Orbiter Processing Facility, and the launch pads. USA also provides spare parts for the orbiters, maintains shuttle flight simulators, and provides tools and supplies, including food, for shuttle missions. About 10 percent of the value of the SFOC pays for shuttle-related activities that support the International Space Station, including training, mission planning, mission operations, and flight equipment and supplies.

SFOC Implementation

In 1995, prior to the SFOC's initiation, NASA had 85 separately managed contracts with 56 contractors. Those contracts were either fully or partially funded by the shuttle program and were used to operate and maintain the shuttle fleet. In 1996, spending on those separate contracts totaled about $3.14 billion. Phase I of the SFOC, begun in 1997, consolidated 12 of the contracts (plus two smaller subcontracts), which had a total cost of about $1.36 billion in 1996. In July 1998, Phase II of the SFOC was initiated to incorporate the activities associated with 15 additional contracts and subcontracts. Those activities included processing of the SRB and maintenance of flight software and equipment used by the flight crew. As a result of Phase II, 1,375 employees of United Space Boosters Inc., Lockheed Martin, and Boeing became employees of USA.

Originally, Phase II was planned to incorporate contracts for maintaining and upgrading the shuttle's main engines, the external tank, and the propellant sections of the SRBs. However, responsibility for those activities has not been added to the SFOC. According to NASA, part of the rationale for excluding those activities was the agency's philosophy that it should continue to separately manage contracts that involved significant development activities. To support the separate-management approach, some NASA officials also cite the results of a study of military space-launch programs, called the Broad Area Review (BAR), which was conducted by the Air Force in 1999. The Air Force commissioned the BAR after a number of launch vehicle failures and near failures. The review's key finding was that the Air Force had been exercising insufficient management and engineering oversight of its contracts for space launch vehicles.

SFOC Fees

The overall fee that USA has earned to date amounts to about 9 percent of the contract's cost measured on an annual basis. The contract establishes several categories of fees that USA can earn, which are based on a variety of criteria, both objective and subjective. The criteria include meeting specific schedules for performing key activities associated with preparing the shuttle for launch; executing a safe, successful mission; and reducing the costs of operating the shuttle.

NASA states that the fee system is structured to meet the program's goals, which are, in order of priority, (1) flying safely; (2) meeting the launch manifest—that is, launching the shuttle and its payloads on schedule; (3) ensuring that the shuttle can be operated and supported throughout its expected design life; and (4) improving the overall shuttle system. Under the contract, USA can earn no fee for cost reduction unless it exceeds expectations for safety. And if NASA determines that USA is responsible, through its acts or omissions, for the loss of an orbiter or for loss of life during the period from the beginning of final launch preparations through the return of the orbiter, USA will lose all fees for the six-month performance period in which the loss occurs.

---

[4] USA does not manufacture the SRB propellant sections (or the external tank or SSMEs). Rather, the contractor receives the SRB sections at the Kennedy Space Center, assembles them to form two boosters, and attaches the boosters to the shuttle's external tank.

NASA's Oversight of the SFOC

Under the SFOC, NASA has the following responsibilities and roles:

- Maintaining ownership of the shuttles and all other assets of the shuttle program;
- Managing the overall process for ensuring the shuttle's safety;
- Developing requirements for major upgrades to all assets;
- Participating in planning shuttle missions and in directing launches and executing flights;
- Performing surveillance and audits and obtaining technical insight into contractor activities;
- Deciding whether to "commit to flight" for each mission; and
- Managing government-to-government relations, including international interactions.

NASA divides management and oversight of the shuttle program among three major centers:

- *The Johnson Space Center* (JSC) houses the Shuttle Program Office and is the primary site for the astronauts' activities, including the selection of flight crews, training and support (under the SFOC), and extravehicular activity. In addition, JSC has primary responsibility for such SFOC-related activities as shuttle flight operations, software, and equipment processing; shuttle integration; and the orbiter.
- *The Kennedy Space Center* has primary responsibility for processing, launch, and landing operations, all of which are conducted under the SFOC.
- *The Marshall Space Flight Center* is primarily responsible for all of the shuttle's propulsion elements, including the external tank, the shuttle's main engines, and the SRBs. The boosters actually have two components: the propellant portions (the reusable solid rocket motor) and the nonpropellant portions, which are also referred to as the SRB. Of those elements, only the nonpropellant portion is currently under the SFOC.

Within NASA and located at the three centers described above are technical management representatives (TMRs), also referred to as subsystem managers, who are responsible for executing the tasks associated with NASA's roles and responsibilities. Within USA, there are associate program managers, each of whom has a counterpart TMR within NASA.

As a result of the SFOC, some of NASA's tasks and positions associated with shuttle oversight and management were moved to USA. They include 425 tasks and 25 positions associated with flight operations; 305 tasks (no positions) associated with ground operations; and 38 tasks (no positions) associated with integrated logistics.

Before the SFOC, NASA's subsystem managers were the primary focal point for all technical issues relating to a shuttle subsystem. Those managers were aware of and took part in day-to-day decisionmaking regarding any technical problems that arose with the shuttle subsystems for which they were responsible. Under the SFOC, the NASA TMRs participate less in daily decisionmaking. They are responsible primarily for overseeing changes in the design of shuttle subsystems and processing, and for resolving anomalies that occur during shuttle flights.

Other Technologically Complex Government Activities

The remainder of this paper examines examples of other activities that the government undertakes by using contractors. The activities span a broad range of effort, and they vary in their annual costs, the types of contracts used, the incentives the contracts contain, how work to be done under the contracts is defined, and how the government oversees the contractors' work. Thus, many of these activities have features that differ from those characterizing NASA's use of contractors to operate the space shuttle. However, all of the subsequent examples involve the government's use of contractors to perform technologically complex tasks.

The Coast Guard's Deepwater Project

The Coast Guard is undertaking a project, which it calls Deepwater, to redesign the way it performs its missions in deepwater regions—that is, regions that are 50 or more nautical miles from the U.S. coastline. That effort involves determining the numbers and types of ships, fixed-wing aircraft, helicopters, and surveillance sensors that the service will need for such missions for the next 30 years.

The first phase of the Deepwater project was a competition conducted in 1997 in which three contractor teams were each awarded a $21 million contract to design a Deepwater "system" for the Coast Guard. After judging the results, the Coast Guard selected Integrated Coast Guard Systems—a joint-venture limited liability company formed by Northrup Grumman and Lockheed Martin—to build the Deepwater system. That single contractor is to provide the Coast Guard with all of the elements that compose the Deepwater system—ships, aircraft, helicopters, and sensors—over a 30-year period. The contractor will also provide whatever other systems are needed to ensure that the system is integrated—that is, that all Deepwater elements can communicate with each other and exchange needed information.

According to the Coast Guard, no other government agency has ever attempted to replace its entire set of core mission systems by using a single contractor instead of a piecemeal approach. Moreover, in contrast to past projects in which detailed specifications were provided to a contractor that then supplied equipment that matched them, the Coast Guard conducted the Deepwater design competition by employing a set of less detailed measures of performance.

After Integrated Coast Guard Systems delivers the ships, aircraft, and other assets that compose the Deepwater system and following a period of transition, the Coast Guard will use its personnel to operate the equipment and perform minor maintenance. Currently, the service employs contractors to perform major maintenance on selected equipment, and it plans to continue that practice. In general, the Coast Guard has not yet determined the role that Integrated Coast Guard Systems will play in maintaining the Deepwater elements. However, it has decided not to purchase the high-altitude unmanned aerial vehicle that is part of the Deepwater system and that will be used to perform surveillance missions but rather to lease it from, and have it maintained by, the contractor.

The Coast Guard has divided the remainder of the Deepwater project into six five-year contracts characterized as indefinite-delivery, indefinite-quantity contracts.[5] Their total potential value is $14 billion to $15 billion. The first five-year contract period has a potential value of $3 billion to $5 billion.

Under the terms of those contracts, the Coast Guard will develop a set of task and delivery orders each year that describe the work that Integrated Coast Guard Systems should accomplish and the equipment that it should deliver. Those task and delivery orders can be structured as either cost-plus-fee or firm-fixed-price arrangements. The contractor may also receive an additional annual award fee if the work performed on all task and delivery orders is deemed satisfactory by the Coast Guard.

At the end of the five-year period of each contract, the Coast Guard will evaluate the contractor's performance. The most important determinants of the service's overall satisfaction with the contractor's efforts will be whether operational effectiveness has been increased and total ownership costs have been reduced. Although the Coast Guard has a once-a-year opportunity to "walk away" from the contract, the contractor is bound to fulfill its contract responsibilities for the full five-year term so long as the Coast Guard wants it to continue doing the work. If, at the end of the five years, either side no longer wants to work with the other, either party can terminate the relationship.

The Evolved Expendable Launch Vehicle

According to the Air Force, the Evolved Expendable Launch Vehicle (EELV) program is a new approach to obtaining the capability to launch satellites into orbit. With the EELV contract, the Air Force states that it is purchasing, for a firm fixed price, not actual launch vehicles but commercial launch services supplied by a contractor that is responsible for ensuring that the services are provided successfully. In a further departure from traditional practices, the Air Force will not pay all of the contractors' costs to design and test the new EELVs. Instead, the service has required the contractor to share in those development costs because of the potential commercial market for the launch vehicles developed under the EELV program. (However, the originally anticipated market has not as yet materialized.)

To initiate the EELV program, the Air Force executed two "other transaction" authority agreements with Boeing and Lockheed Martin in October 1998.[6] Underthose

[5] The contracts do not specify the exact numbers and types of items that the contractor must provide to the Coast Guard during each five-year period. Those details will be decided yearly and will depend on a number of factors, including available budgetary resources.

[6] "Other transaction" agreements are financial assistance or acquisition arrangements other than procurement contracts, grants, or cooperative agreements. The "other transaction" authority contained in title 10, section 2371, of the U.S. Code permits the military to enter into such arrangements to carry out basic, applied, and advance research projects without regard to statutes or regulations that constrain the use of contracts, grants, or cooperative agreements.

agreements, the government provided $500 million to each contractor to develop a family of EELVs. According to the Air Force, each contractor has also spent from $1.5 billion to $2 billion of its own funds on EELV development.

Currently, the EELV program comprises two families of launch vehicles, the Delta IV and the Atlas V; there are multiple versions of each vehicle to meet the demand for medium-, intermediate-, and heavy-weight payloads. The first Lockheed Martin vehicle, the Atlas V, flew on August 21, 2002, and the first Boeing vehicle, the Delta IV, flew on November 20, 2002. Both flights were successful but carried commercial payloads. The first Air Force payload was successfully launched by a Delta IV on March 10, 2003.

Rather than eventually selecting a single contractor, the Air Force expects to engage continually in competitions between Boeing and Lockheed Martin to procure launch services using EELVs. The Air Force states that this continual competition is needed to ensure that the United States always has the means available to launch spacecraft.

In 1998, the Air Force awarded initial launch services contracts for 26 EELV launches: 19 Boeing Delta IV launches, for a total of $1.5 billion, and seven Lockheed Martin Atlas V launches, for a total of $506 million. The Air Force anticipates awarding a second set of contracts in the summer of 2003 for up to four launches and a third set of contracts in the fall of 2003 for up to 18 launches. Recently, as a penalty for Boeing's unlawful possession of a competitor's proprietary information, the Air Force reduced the initial Boeing contract to 12 launches and increased the initial Lockheed Martin contract to 14 launches. In addition, the Air Force also disqualified Boeing from competing for three additional launches and awarded them to Lockheed Martin.

The Air Force's EELV program office is located in Los Angeles, with additional personnel located at both the eastern (Cape Canaveral) and western (Vandenberg Air Force Base) launch ranges. The program office currently employs 76 Air Force personnel to manage the EELV program. Lockheed Martin and Boeing together have approximately 3,600 employees to manufacture and launch their respective versions of the EELV.

Four key performance parameters have been established for the EELV program: mass-to-orbit specifications, reliability, standard payload interface, and a standard launch interface.[7] Under the launch services contracts, a launch service is deemed complete and accepted with the intentional ignition of the first-stage engine and the first intentional detonation of the first-stage tie-down of the launch vehicle. In other words, the contractors are responsible for ensuring that an EELV successfully ignites and begins to lift off the launch pad—but not for ensuring that the Air Force spacecraft it carries successfully reaches orbit.

There are no incentive or award fees in any EELV program contract. According to the Air Force, the contractors are expected to launch successfully in order to increase their competitiveness in the marketplace. Consequently, the government does not have penalty clauses associated with the EELV contract in the event of the loss of a vehicle. (Rather, the penalty to the contractor would be the potential loss of future business from government sources and commercial firms as a result of the failure.) Both contractors, in what is known as the "best-customer clause," guarantee that they will not sell a commercial launch service using an EELV for less than the cost that the government has negotiated for a similar launch service.

The Air Force states that it has relied heavily on "insight" rather than "oversight" in conducting the EELV program. For example, the service notes that it has not required the contractors to provide the government with special or unique documentation or data. Instead, the government has relied on the same documentation that the contractors use to manage their respective programs.

The Future Combat System

Traditionally, in developing battlefield weapon systems, the Army has established separate programs for each system—such as the Abrams tank or Comanche helicopter—relying on a prime contractor to develop each one. But in the case of the Future Combat System (FCS), the Army's next generation of weapons, the service is using a nontraditional approach that assigns substantial authority to a single contractor. That contractor, referred to as the lead system integrator (LSI), will de-

[7] There are seven mass-to-orbit standards that specify given masses to given orbits—for example, the launch vehicle must get 17,000 pounds of payload into a low Earth orbit with a certain inclination. The vehicle's design reliability must be at least 98 percent. The Air Force has specified a standard interface for accommodating payloads that each vehicle must be capable of providing. The launch interface requirement states that medium, intermediate, and heavy versions of a launch vehicle must be able to be launched from the same pad.

velop and integrate 18 different systems—new families of manned and unmanned ground vehicles and unmanned aerial vehicles—to replace the service's current fleet of tanks, armored vehicles, self-propelled howitzers, and various other systems.[8] The Army has contracted with Boeing—which has teamed with Science Applications International Corporation—to act as the LSI and to coordinate the development, testing, and production of all 18 systems, their associated sensors, and the communications networks to connect them all.

According to the Army, the LSI will "develop, manage, and execute all aspects" of the program, acting as the government's industry partner.[9] In that role, the LSI will undertake many of the activities that the Army would have performed under a more traditional approach. Those activities include issuing requests for proposals (RFPs); developing performance requirements for FCS as a whole as well as for individual systems and subsystems; evaluating responses to the RFPs; and, with the Army's concurrence, awarding the contracts to develop the individual systems. The LSI will also design tests, analyze system performance trade-offs, and manage production. The Army has used "other transaction" authority agreements in executing contracts for FCS and states that it believes that "FCS is larger and more complex than traditional developments, and thus requires an alternative procurement approach." As a consequence, the Army chose to rely on an LSI "after studying lessons learned by the National Aeronautics and Space Administration's (NASA) space station and the Missile Defense Agency's (MDA) Ballistic Missile Defense Systems approaches to designing and developing extremely large and complex systems of systems projects." [10]

During the concept and technology development stage from March 2002 through June 2003, Boeing was responsible for developing, delivering, updating, and maintaining an overarching architecture for all of the systems included in FCS; supporting the Army's Training and Doctrine Command in refining operational concepts and requirements; identifying and evaluating potential concepts and technologies; conducting demonstrations; and developing performance specifications and the documentation to support a successful transition to the system development and demonstration (SDD) phase of the project. As part of that effort, Boeing issued 23 RFPs for development tasks to be performed during SDD and evaluated the responses in preparation for awarding the contracts in the fall of 2003. For work performed during the concept and technology development stage, the government agreed to pay Boeing a total of $154 million.

The government recently exercised its option under the concept and technology development contract to extend its agreement with Boeing to include the system development and demonstration phase. Activities to be performed by the LSI during that phase include managing the design, manufacture, and testing of prototypes; evaluating whether the systems are ready for production; identifying and performing the tests and producing the documentation needed to enter the next phase of the acquisition process; providing detailed cost estimates and cost reports; and supporting Army personnel who will use the equipment once it is fielded. Boeing, in conjunction with government representatives, is also responsible for awarding contracts for the 23 systems and subsystems that were defined in the concept and technology development phase. The SDD phase of the FCS program is estimated to extend through December 2011, with the total value of the contract currently set at $14.9 billion and annual funding levels ranging from $1.3 billion to $4.3 billion.

Although the Army signed a contract with the LSI on May 30, 2003, to perform the work described above, the final details have yet to be settled. In fact, one of the tasks to be completed during the first seven months of the contract is to establish the fee structure and criteria that will apply to the remainder of the contract (that is, from early 2004 until December 2011) and to reconcile Boeing's projected expenditures with the government's projected funding and the program's scope of work.[11] Other tasks that Boeing must perform include updating the technical specifications; demonstrating command-and-control software; evaluating or negotiating all 23 subcontracts for which RFPs were let and fully defining at least 85 percent of them;

---

[8] The total cost for equipping all of the Army's maneuver brigades with FCS could be as high as $300 billion.

[9] Department of the Army, "The Lead System Integrator (LSI) Agreement for the Future Combat System (FCS) Program," Army Information Paper (June 18, 2003), provided to the Congressional Budget Office.

[10] *Ibid.*

[11] Department of the Army, *Agreement Between the Boeing Company and U.S. Army Tank-Automotive and Armaments Command Concerning Future Combat System (FCS) System Development and Demonstration (SDD) Phase,* DAAE07–03–09–F001 (May 30, 2003).

and reaching agreement on the staffing of integrated product teams (IPTs), which include both contractor and government personnel.

A total of $130 million has been allocated to this effort for 2003, with an additional $60 million planned for 2004. Of that total $190 million, a base fee of $10 million has been set aside for Boeing with an additional $15 million available in incentive fees. The incentive is structured to motivate Boeing to complete the tasks described above—and in particular to establish the final details of the contract—before the end of December 2003.[12]

Although the government will retain ultimate control of the FCS effort, the program's management structure—in which the LSI and the Army form integrated product teams—gives the contractor extraordinary responsibility and authority. The agreement signed in May 2003 envisions IPTs at several levels. The highest would be the program management team cochaired by the LSI program manager and the Army's FCS program manager. Below that would be 14 second-tier IPTs, each of which would also be cochaired by representatives of both the LSI and the government.

Decisions by IPTs are expected to be reached by consensus between the cochairs, but the contract also includes a mechanism for settling disputes. In cases in which consensus cannot be reached, the decision of the LSI cochair will prevail. Government cochairs can initiate a request for review of decisions with which they do not concur but must do so in writing to the next-higher-level IPT and propose an alternative approach to the disputed decision as well. The same hierarchical rules apply to the higher-level IPTs—that is, the LSI cochair has the final say. The highest decisionmaking authority for an issue raised through this process is the LSI program manager. However, any appeal that the LSI program manager does not support must be reported to the Army's FCS program manager. Ultimately, it is the Army's FCS program manager who has not only the final word but also the authority to override the LSI program manager's decision and direct that changes be made to the program.

Lawrence Livermore National Laboratory

Since 1952, the Department of Energy (DOE) and its predecessors have contracted with the University of California for management and operations (M&O) of the Lawrence Livermore National Laboratory (LLNL). Under the contract, the university is responsible for managing, operating, and staffing the lab; accomplishing the missions assigned to it; and administering the M&O contract with DOE.

LLNL was established in 1952 as a facility dedicated to research on and development of nuclear weapons designs. The lab encompasses two sites covering a total of almost 8,000 acres; it has 600 buildings and employs about 5,400 personnel. Its current missions include ensuring that the Nation's nuclear weapons remain safe, secure, and reliable; acting as a steward of U.S. nuclear weapons through activities ranging from dismantling weapons to remanufacturing the enduring stockpile; ensuring the availability and safe disposition of plutonium, highly enriched uranium, and tritium; assisting in remediation and reduction of wastes from the nuclear weapons complex; and helping to deter, detect, and respond to the proliferation of unconventional weapons. DOE's total obligation to the university in 2002 for managing and operating LLNL was $1.6 billion.

The ultimate responsibility for executing the contract lies with the regents of the University of California, who have delegated management and oversight authority to the university system's president. The president, in turn, appoints the director of the lab (subject to the regents' and DOE's approval). The university oversees the three national labs that it manages for DOE (the other two are Los Alamos National Lab and Lawrence Berkeley National Lab) through the office of the vice president for laboratory management as well as through a regents' committee, a president's council, and two additional senior-level councils and committees.

DOE oversees operations at LLNL through its Oakland Field Office, which maintains about 140 personnel at the LLNL site. The assistant manager for National Nuclear Security Administration (NNSA) operations in the Oakland Field Office heads the LLNL site office and reports to the manager of the Oakland office. DOE's representatives at the LLNL site office are responsible for ensuring that nuclear activities at LLNL are carried out safely and in accordance with current laws and regulations. In particular, the NNSA staff at the site office oversee nuclear research, nuclear safety, and related matters, and the environmental management staff at the

[12] Starting on December 30, 2003, and every 30 days thereafter, the $5 million incentive fee for working out the final details of the contract will be reduced by $800,000. If the contract is not fully defined by the end of May 2004, Boeing will not receive any of the $5 million incentive fee.

field office oversee environmental restoration and waste management activities, including the construction of a new waste treatment facility. Thus, the lab must gain approval from its DOE overseers before proceeding with new construction or operations.

The existing contract between DOE and the University of California was signed in January 2001 and extends through September 2005. Because LLNL is a federally funded research and development center, the contract for its management and operation is exempt from competition and is merely an extension of the original 1952 contract between DOE and the university. However, the current version of the contract incorporates revisions that reflect DOE's updated acquisition requirements. The contract also includes performance objectives and measures that DOE began to include in its contracts in the mid-1990s in response to widespread calls for reform.

The LLNL contract, as revised for 2003, includes nine performance objectives, each of which is supported by as many as eight performance measures.[13] Performance objectives are negotiated annually, before the start of the fiscal year, with performance tracking and reporting carried out by the contractor throughout the year. Evaluations and assessments of the university's progress based on the performance objectives and measures are conducted annually by the university and by DOE, and part of the compensation that the university receives for managing LLNL is an adjustable fee based on those evaluations. In 2003, for example, an adjustable fee based on performance could account for $4.3 million of the $7.1 million that the university may receive in compensation unrelated to the direct costs of managing and operating LLNL. (The remaining $2.8 million is fixed and covers the university's indirect costs.)

Logistics Support for the B–2 Bomber

Contractors are significantly involved in certain support activities for B–2 bombers, specifically aircraft maintenance, aircraft modifications, and training. In comparison, Air Force units perform mission planning and payload preparation. Contractors provide some assistance in those latter two activities (for example, by helping keep automated mission planning tools up to date and functioning), but the Air Force considers the planning of strikes and the loading of munitions on the bombers to be inherently military tasks that should be performed by Air Force support squadrons and by the Air Force personnel who compose the bomber squadrons.

B–2 maintenance is performed both by contractors and by Air Force personnel. In general, the Air Force handles maintenance when the aircraft are with the 509th Bomb Wing; it uses a contractor to perform the bombers' periodic and much more extensive programmed depot maintenance (PDM). There is, however, some contractor support on the flight line. For example, a few contractors work at Whiteman Air Force Base, where the B–2s are based, to help with issues that might arise with the special low-observable surfaces on the aircraft or with its engines.

Much of the PDM work that is done under contract involves replacing the bombers' exterior low-observable coatings, a very specialized task on the B–2. A study of PDM alternatives conducted by the Air Force in the mid-1990s determined that the facilities and skills needed for that special coating maintenance as well as for maintenance activities associated with other unique aspects of the B–2 could best be provided by Northrop Grumman, the B–2's original manufacturer. As a result, the overhauls are conducted at Northrop Grumman's Plant 42 facility in Palmdale, California.

Much of the contract work for the B–2 is consolidated under an umbrella flexible acquisition sustainment team (FAST) contract with Northrop Grumman. The FAST contract does not itself define the work to be performed. Rather, it serves as a vehicle by which individual work orders tailored to the specific maintenance needs of individual aircraft can be executed.

Since the B–2 program is relatively young and the PDM cycle is seven years, the PDM arrangement has been in place only since 2000. A so-called delivery order for

[13] Those standards are spelled out in Modification No. M456, Supplemental Agreement to DOE Contract No. W–7405–ENG (revised March 4, 2003)—specifically, in Appendix F, Standards of Performance. One example is the performance objective to use the university's strengths to recruit, retain, and develop the workforce. The university's progress in meeting that objective is to be judged on the basis of two performance measures: first, providing the skills necessary to enhance the science base by implementing recruiting and retention strategies; and second, implementing leadership and management development programs aligned with workforce planning and diversity objectives. Another example of a performance objective is the one for maintaining a secure, safe, environmentally sound, effective and efficient basis for operations and infrastructure. That objective is supported by eight performance measures, of which developing a long-term plan with DOE to reduce inventories of surplus and excess special nuclear material and onsite waste is an example.

PDM is executed annually under the FAST contract, whose yearly value is about $60 million and typically includes work on two aircraft. According to the Air Force, the initial annual contracts were set up as cost-plus-award-fee arrangements because the specific nature and extent of the maintenance that would be required was not well understood. With the experience gained under the work conducted over the period from 2000 to 2002, the Air Force has begun to execute PDM contracts as firm-fixed-price agreements.

The PDM contracts also have incentive aspects (notwithstanding the firm-fixed-price feature), which include a program for reduction in total ownership costs (RTOC). The goal of the program is to reduce the Air Force's overall costs for maintaining the B–2 without impairing essential system functions or performance characteristics. Savings from RTOC initiatives are shared with the contractor.

As with maintenance, B–2 training is split between Air Force and contractor personnel—who are provided by the Link Simulation and Training Division of L3 Communications, Inc. (formerly Raytheon and before that, Hughes). Contractor personnel are involved in operating, maintaining, and modifying the B–2 training systems. Link operates and maintains the aircrew and maintenance training devices and also develops and modifies maintenance training courses. Course development and academic instruction for the B–2's aircrews are provided by Northrop-Grumman under a subcontract to Link, with Air Force instructors supplementing that instruction. In addition, Link operates and maintains the Weapons Loading Trainer.

Those contractor-performed training activities are covered under the Training System Contractor Logistics Support Contract, for which Link is the prime contractor. The period of performance on the $325 million contract is eight years.

National Missile Defense—National Team

In order to define the elements of its "layered" missile defense concept and the manner in which those elements will interact, the Missile Defense Agency within the Department of Defense turned to a largely contractor-staffed organizational structure called the National Team. In addition to contractors, the National Team consists of employees from the Department of Defense and federally funded research and development centers (such as the Aerospace Corporation); it is divided functionally into two major components: one for systems engineering and integration (SE&I) and the other for integrating battle management, command, control, and communications (BMC2&C). Those two teams, as they are known, interact with MDA personnel in designing and developing an overall missile defense system.

According to MDA, a key feature of the National Team is that the two teams are behind a "firewall," which separates them from other contractor personnel who are developing missile defense hardware. That arrangement was necessary because the prime contractors leading the national teams are also engaged in weapon system development and production. National Team contractors must thus sign conflict-of-interest and associate contractor agreements to ensure that information—including proprietary data that team members employed by individual contractors would otherwise not be free to share—flows between the SE&I and BMC2&C teams.

The SE&I team is led by Boeing, with participation from Lockheed Martin, and the BMC2&C team is led by Lockheed Martin, with participation from Boeing. General Dynamics, Northrup Grumman/TRW, and Raytheon are also represented on both teams. The role of the SE&I team is to define a "toolbox"—consisting of weapons, sensors, and communications components—and integrate those systems to forge a single, layered ballistic missile defense system (BMDS). The SE&I team's responsibilities also include characterizing the threat environment. The role of the BMC2&C team is to develop the components for planning, control, monitoring, and execution of the BMDS.

MDA used "other transaction" authority agreements with Boeing and Lockheed Martin to form the National Team. The period of performance for both the SE&I's and the BMC2&C's agreements is divided into two parts. Part I lasts for four months; its tasks include definition of the BMDS processes and an initial assessment of the system's elements. Part II, which lasts for 10 years, covers the design, modeling and simulation, and virtual prototyping of the BMDS. Part II is structured as a two-year base contract, followed by four two-year options. Together, both Part I contracts (SE&I and BMC2&C) total about $28 million. MDA estimates that funding for Part II of the SE&I contract and Part II of the BMC2&C effort will total $953 million and about $1.7 billion, respectively.

The National Team contracts are structured as cost-plus-award-fee arrangements, with the fee amount based on a mix of subjective and objective criteria. The total award fee available through December 2003 for the SE&I contract is $34.5 million; $30.8 million is available for the BMC2&C contract.

Refueling/Overhauls for Aircraft Carriers

The Navy's nuclear-powered aircraft carriers must be refueled and overhauled periodically throughout their 40- to 50-year lifetimes. Only one shipyard in the United States—Newport News, owned by Northrup Grumman—is capable of undertaking the required work. The Navy provides Newport News with nuclear fuel and detailed specifications for refueling the carrier's reactor and overhauling the other ship's systems. The work performed by Newport News includes removing the expended nuclear fuel, installing new fuel, and delivering the expended fuel to the Navy for storage and disposal. Newport News also assists in conducting sea trials of the refueled and overhauled carrier prior to its return to operations.

The Navy uses sole-source contracts to perform the refueling overhauls and structures them as cost-plus-award-fee arrangements. Newport News and the Navy negotiate a target cost for the work and a target fee. In the most recently awarded contract, which was for refueling and overhauling the USS *Carl Vinson,* the fee component of a total $1.52 billion contract was $144 million, or about 10 percent. Under the terms of the contracts, Newport News can earn an additional fee amount (up to a preset maximum) for underrunning the cost target but will lose part of the fee (down to a preset minimum) if costs exceed the target.

Every carrier undergoing maintenance has a detailed list of specifications developed by the Navy as to how the work is to be done. Any work that cannot meet the specifications must receive a waiver from Naval Sea Systems Command (NAVSEA), which oversees work performed by Newport News.

Newport News is responsible for developing and following a quality control process and for performing quality assurance. NAVSEA personnel monitor and audit the shipyard work and perform random sampling to ensure that Newport News is following its quality control and assurance processes. That oversight is carried out by the Navy's supervisor of shipbuilding, conversion, and repair (SUPSHIP) located at Newport News. The Naval Nuclear Propulsion Program (commonly known as Naval Reactors) also has an office at the shipyard to monitor the process of refueling the carrier. All work done by the contractor must pass a final inspection by NAVSEA to ensure that the work has been done to all specifications before being accepted.

Once the ship is delivered and accepted, it goes through a series of sea trials, which the Navy performs over a three-to four-month shakedown period. Every system on the ship is tested, and the carrier is pushed to its limits to ensure that it can perform properly upon its return to operations. The ship must receive a series of certifications from the Navy to show that it passed all the tests. After that, there is an eight-month postshipyard availability during which the contractor must fix all items discovered during the trials that did not meet the specifications or pass the at-sea tests. The Navy covers the cost of resolving problems identified during the sea trials.

The Savannah River Site

The Department of Energy's Savannah River Site (SRS) was constructed during the early 1950s to produce and separate plutonium and tritium for nuclear weapons. In 1989, the Westinghouse Savannah River Company (WSRC) took over the contract with the Department of Energy to manage and operate the facility, which had been held since 1950 by the E.I. duPont de Nemours Company.

Since the mid-1990s, the bulk of the activities at Savannah River have involved managing the storage and treatment of radioactive waste from production activities, the storage of special nuclear materials such as components from dismantled weapons and spent nuclear fuel, and the recycling of tritium from surplus nuclear weapons. The site covers a total of 198,000 acres (or 310 square miles) and employs about 13,000 personnel. Under the current contract, WSRC is responsible for providing the personnel, equipment, materials, supplies, and services necessary to manage and operate the site.

Oversight of the contract is provided by about 400 DOE staff at the Savannah River Operations Office (SRO), which is located on the Savannah River site. The manager of the SRO is responsible for contract management and oversight of the site's environmental restoration and waste management activities, which represent about 80 percent of all work that DOE has contracted for there. (An assistant manager of the SRO is responsible for overseeing stewardship of the Nation's stockpile of nuclear weapons and materials; those stewardship duties constitute the remainder of the activities at SRS and fall under the purview of the National Nuclear Security Administration.) WSRC is responsible for managing the work of a team of contractors and subcontractors at SRS. The team includes Bechtel Savannah River and BNFL, Inc., which together manage engineering, design, and construction activities; and BWXT, which handles shut-down, decontamination, and decommissioning of excess facilities. BNFL, Inc., also manages solid waste activities.

The existing contract between DOE and WSRC is an extension of the contract that was awarded competitively to WSRC in 1997; it was signed in early 2001 and extends through the end of September 2006. DOE's total obligation to WSRC from October 1, 2000, through September 30, 2006, is $8.4 billion, yielding average annual allotments of $1.4 billion. Under the contract, WSRC is responsible for five major groups of activities:

- Performing environmental restoration tasks such as identifying, characterizing, and assessing waste units and affected groundwater; preparing plans for closing selected facilities; managing remediation of waste sites; monitoring inactive waste-and groundwater units; and accelerating early remediation activities;
- Decontaminating and decommissioning excess facilities, including several produc tion reactors and chemical processing facilities;
- Developing new areas of research and development;
- Managing the site's nuclear programs, which include the processing of tritium, and supporting long-term planning to maintain the tritium supply and stabilize and store existing inventories of nuclear material; and processing high-level waste for eventual long-term storage or disposal; and
- Providing site support by protecting human health and safety and the environment in all activities; managing the design and construction of new facilities; providing operational support such as utilities, transportation, and maintenance and repairs; and supporting long-range and strategic planning for the site.

The contract between WSRC and DOE includes a multiyear fee "pool" of $345 million to fund performance-based incentive awards over the contract's six-year term. Performance incentives and measures are negotiated before the beginning of each Fiscal Year and are used to determine annual awards. In March 2001, the Defense Nuclear Facilities Safety Board raised concerns that the incentives could encourage waste processing at the expense of safety.[14] However, an internal DOE review conducted in response to those concerns concluded that the incentive structure in place did not compromise safety and that it correctly emphasized waste processing.[15] Moreover, it concluded that the onsite DOE representatives responsible for monitoring the contract, in order to stress DOE's safety concerns, had appropriately reduced the contractor's award fee to reflect less-than-acceptable performance.

In July 2002, the assistant secretary for environmental management at DOE initiated an internal review of the incentive structure at SRS as part of an effort to ensure that incentives in DOE's major site contracts were properly linked to its overall strategic plan for environmental management and the strategic plans of the individual sites.[16] In the case of SRS, DOE's review team concluded that the site's contract incentives were not designed to accelerate risk reduction and closure (two goals of DOE's environmental management efforts) but rather to motivate cost savings.[17] In response to that finding, WSRC and the SRO, at the direction of the assistant secretary, revised the performance objectives and incentives in the SRS contract for 2003 to better align them with DOE's environmental management goals.

Trident Ballistic Missile Submarine Conversions to Perform Conventional Missions

The Trident submarine conversion program will convert four existing Ohio classTrident submarines, which formerly performed strategic nuclear missions, to a conventional configuration that will provide special operations and conventional strike capabilities. The program comprises activities to manufacture the "kits" required to convert the four submarines, conduct engineering refueling overhaul (ERO) of the four ships' nuclear reactors, and install the conversion kits. The conversion kits consist of lock-out chambers and associated equipment for use by special operations personnel, launch tubes (multiple all-up-round canisters) for conventional Tomahawk missiles, Tomahawk missile fire-control systems, and information management and communications equipment.

The initial work on the program (such as concept and initial design studies) began in 2000, and detailed design efforts commenced in 2002. Refueling overhauls and conversion kit manufacturing and installation will take place between 2003 and

---

[14] Defense Nuclear Facilities Safety Board, *High-Level Waste Management at the Savannah River Site,* Recommendation 2001–1 (March 23, 2001), p. 5.

[15] Department of Energy, Independent Review Team, *Independent Assessment of the Savannah River Site High-Level Waste Performance Based Initiatives,* EM–INTEC–02–008 (December 2001).

[16] Memorandum from Jessie Hill Roberson, Assistant Secretary of Energy for Environmental Management, to various DOE field offices, "FY2003 Contract and Performance Objectives and Incentives for Environmental Management," July 2, 2002.

[17] Department of Energy, *Savannah River Site Trip Report* (July 9, 2002).

2007. The first ship in the line (USS *Ohio*) is expected to be operational in its new configuration in 2007. The four conversions are expected to cost $4 billion over the period from 2000 through 2009.

The Navy plans to carry out the conversion program by using a public/private partnership approach. The conversions begin with the installation of a new reactor core (the ERO) in each submarine. Public shipyards—the Puget Sound Naval Shipyard on the West Coast and the Norfolk Naval Shipyard on the East Coast—will each perform two refueling overhauls as part of the overall program. Those shipyards will also provide a portion of the technical labor and other services and support required to install the conversion kits in the four submarines, work that will be managed by a contractor but performed at the public shipyards. The Electric Boat (EB) division of General Dynamics Corporation will design and manufacture the conversion kits and manage their installation, including providing most of the labor needed for that task.[18] EB is designated as the conversion execution manager—the single entity responsible for the conversion kit's design, manufacture, installation, and testing.

EB's installation of the kits and its testing activities will use the Navy's labor resources at the public shipyards. The shipyards will, in effect, operate as a subcontractor to EB under the conversion installation contract. That is, EB will receive money under the cost-plus-fee contract for the "touch labor" provided by the public shipyards and will then reimburse them for the cost of the labor that they have supplied.[19]

EB's work on the design and manufacture of the conversion kits is being done under a sole-source cost-plus-fixed-fee contract that includes performance incentives.[20] The contract has two main parts. The first, which is worth about $400 million, covers the detailed design of the conversion kits and ship modifications. The second part, totaling about $116 million, covers the procurement of materials needed for the conversion. Each portion of the contract has a total available fee of 10 percent, including incentives for timeliness and cost control.

The other major contracts in the conversion program are for the multiple all-up-round canister (MAC), designed and manufactured by Northrop Grumman Marine Systems, and the attack weapon control system (AWCS), designed and manufactured by General Dynamics Advanced Information Systems. The contracts for the MAC (totaling $155 million) and AWCS (totaling $117 million) are both of the cost-plus-incentive-fee type. For the MAC, the maximum fee is 16 percent; the maximum fee for the AWCS is 15 percent.

A Trident submarine conversion program office established within Naval Sea Systems Command is responsible for the overall management and technical oversight of the conversion program and retains approval authority for critical design elements.[21]

The Navy's supervisor of shipbuilding—EB Groton Office—is the supervising authority and administrative contracting officer for all EB work (specifically, the de sign, manufacture, installation, and testing of the conversion kits). SUPSHIP Groton oversees and certifies the conversion work on behalf of NAVSEA. The public shipyards perform the refueling overhauls under NAVSEA's oversight.

---

[18] Other contractors (Northrop Grumman Marine Systems and General Dynamics Advanced Information Systems) are also involved in the design and manufacture of the systems that go into the conversion kits. However, EB is responsible for the overall integration of the systems with those of the ship.

[19] The authority for the shipyards to undertake this type of arrangement derives from the Center of Industrial and Technical Excellence (CITE), which allows a government entity with exceptional technical capabilities to provide services to a private party if doing so benefits the government. According to the Navy's cost accounting and funding rules for its shipyards, EB will be charged the variable costs of using the labor, while the fleet, as "owners," will foot the bill for the shipyard's facility and administrative overhead.

[20] The noncompetitive procurement stems from two factors: EB was the original designer and manufacturer of these Ohio class submarines, and the Navy has determined that the project's time schedule does not permit a competitive procurement.

[21] In 2002, NASA and NAVSEA initiated the NASA/Navy Benchmarking Exchange to examine the Navy's submarine safety assurance program and compare its features with NASA's safety program for the space shuttle. The goal was to identify a set of lessons learned that could benefit NASA. The two organizations published an interim report in December 2002 outlining similarities in and differences between the design, test, operation, and maintenance of submarines and the shuttle. In the report, NASA identifies potential opportunities for change that it should consider, including the implementation of the NAVSEA organizational model for submarine safety compliance verification, which would establish within NASA an office independent of the shuttle program to verify compliance with safety procedures and measures; and the development of a comprehensive set of detailed and specific NASA safety requirements that its future human-operated space systems must meet.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO HON. SEAN O'KEEFE

Question 1. After reviewing the Board's report, do you believe that the proposed March 2004 date for return to flight is still valid?

Answer. The March–April 2004 launch window was set for planning purposes only. This target date allowed the program to establish milestones for the return to flight process, and the Space Shuttle program will not return to flight until those milestones have been fully met. The CAIB made 15 Recommendations that must be resolved before return to flight. Assessing those recommended actions and our technical progress to date; we have revised our launch-planning window to September-October of 2004. We will not commit to launch again until we, in concurrence with the Stafford-Covey Task Group, have assessed our completion of the Return-to-Flight actions and advised the NASA Administrator that we are "fit to fly."

Question 2. NASA has established a task group headed by veteran astronauts, retired U.S. Air Force Lieutenant General Thomas Stafford and Space Shuttle commander Richard Covey, to perform an independent assessment of NASA's actions to implement the Board's recommendations. How will you ensure that this task group is fully independent, and will make sure that the Board's recommendation will be implemented?

Answer. The Return to Flight Task Group is chartered under the Federal Advisory Committee Act. As such, the Task Group operates under statutory procedures that help insure its independence. For instance, all documents considered by the Task Group are made available to the public and all meetings where the Task Group deliberates to make its consensus decisions in advance must be open for public scrutiny. To further insure its independence from scheduling or any other programmatic pressures the Stafford-Covey Task Group reports directly to the NASA Administrator, not to the Office of Space Flight or Space Shuttle Program. The 28 members have been chosen for their knowledge in a wide range of issues, from space flight to management of complex organizations, and have indicated their willingness to undertake public service. Of the 28 members of the Stafford-Covey Task Group, only ex-officio member Mr. James D. Lloyd is a current NASA employee. The members of the Stafford-Covey Task Group have already demonstrated their independence of opinion in their interactions with Admiral Gehman.

Question 3. The Board report has stated that NASA's culture played a role in the *Columbia* accident, and viewed the agency's "cultural resistance as a fundamental impediment to NASA's effective organizational performance." In the weeks before the report was released, senior NASA officials were quoted as downplaying the role of culture in the accident. What specific actions do you intend to take to shake up NASA's culture and break down its resistance to outside recommendations?

Answer. NASA accepts the CAIB Recommendations calling for a more independent Safety and Mission Assurance organization, a reorganized Space Shuttle Integration Office that is responsible for the flight performance of all Space Shuttle elements, and an independent Technical Engineering Authority that will exercise ownership of Space Shuttle failure mode, effects analysis, and hazard reporting systems. The new NASA Engineering and Safety Center will be one part of this reorganization strategy, and will serve as the basis for opening up new avenues of communication and promoting a culture of safety through engineering excellence. Additional organizational changes are under review.

Fourteen of the senior managers on the Space Shuttle program are new to their positions. They and the NASA Administrator are responsible for emphasizing that all elements of the Agency understand the role of free and open communication. Through them, NASA will actively encourage people to express dissenting views, even if they do not have the supporting data on hand, and create alternative organizational avenues for expressing those views.

NASA will continue to seek the participation of independent experts from outside the Agency, including the Stafford-Covey Task Group, Aerospace Safety Advisory Panel, the NASA Advisory Council, the NASA Office of the Inspector General, and others.

NASA will take aggressive action to identify areas where we can improve our culture and take action to do so. NASA will take the following steps as stated in NASA's Implementation Plan for Return to Flight and beyond.

- Create a culture that values effective communication and empower and encourage employees to take ownership over their work processes.
- Assess the existing safety organization and culture to correct practices detrimental to safety.

- Increase our focus on the human element of change management and organizational development.
- Remove barriers to effective communication and the expression of dissenting views.
- Identify and reinforce elements of the NASA culture that support safety and mission success.
- Ensure that existing procedures are complete, accurate, fully understood, and followed.
- Create a robust system that institutionalizes checks and balances to ensure the maintenance of our technical and safety standards.
- Work within the Agency to ensure that all facets of cultural and organizational change are continually communicated within the NASA team

NASA has proactively focused on cultural change starting in July 2002 when the Administrator formed the One NASA team. The team's objectives included defining the actions needed to create a more unified NASA organization and formulating a set of specific recommendations for organizational and cultural change that can elevate NASA to a new level of effectiveness and performance. The One NASA team has identified a set of recommendations and actions to senior management, which are being implemented. Since the release of the CAIB report, the Agency is evaluating how the cultural issues raised by the Board can be addressed by this ongoing activity and other culture change activities in the near future.

One specific area of concern from the Board's report was the operation of the Shuttle's Mission Management Team (MMT) at Johnson Space Center (JSC). NASA has quickly moved out to address that concern and has made some major changes. In perhaps the most convincing way yet that NASA "gets it," the new chairman of the MMT outlined some major changes to improve communications among engineers and managers, to ensure dissenting views are heard and to correct the cultural shortcomings blamed in part for the *Columbia* disaster. New members will be added to the MMT and outside experts will be brought in to coach the managers on decision-making skills and regular mission simulations will be held to test those skills in make-believe emergencies.

The new chairman stated that his basic model of management would be consensus. Consensus style of management will open lines of communication to make sure people get their dissenting and minority opinions on the table. In the near to long term, outside safety and management experts will be brought in on a regular basis as part of a continuing education program.

The above is one of many changes and activities that are already ongoing at NASA to bring about the desired cultural change the Board recommended.

Question 4. The Board analyzed two possible scenarios that might have been used for rescuing the *Columbia* crew: repairing the damage on orbit or rescuing the crew with the *Atlantis.* The Board found that the option using *Atlantis* "had a considerably higher chance for bringing *Columbia*'s crew back alive." Had NASA done any training or simulations prior to the *Columbia* accident for what to do in case of a major tile loss or Reinforced-Carbon—Carbon breach on an orbiter? What are NASA's plans for dealing with a potential similar crisis in the future, and is NASA currently training astronauts to do an orbiter-to-orbiter transfer as is discussed in the report?

Answer. NASA had conducted a number of engineering studies as to the efficacy of on-orbit repair of Space Shuttle tiles between 1979 and 1981. Before the first launch of the Space Shuttle in April 1981, Shuttle program managers were most concerned with a "zipper" effect during flight, whereby the loss of a single whole tile would initiate the loss of large areas of tile. Engineering data showed that some surface damage to tiles in flight, short of the loss of a whole tile, did not jeopardize the thermal design requirements for the vehicle. When later analysis and flight tests showed that the Space Shuttle tile system was not as vulnerable to zippering due to the loss of single tiles, the in-orbit tile repair research was cancelled. No similar work was done for on-orbit Reinforced-Carbon-Carbon (RCC) repairs.

Instead of an orbiter-to-orbiter crew rescue procedure in the case of future, irrecoverable damage to a Space Shuttle on-orbit, NASA is evaluating the feasibility of providing a lower-risk Contingency Shuttle Crew Support (CSCS) capability. CSCS is a contingency capability that will provide another response to known, but remote, risks and circumstances. In the event of an on-orbit emergency precluding reentry and landing, the Shuttle orbiter would transfer its crew to the ISS. The crew would remain on the ISS until they could be returned to Earth.

Question 5. Last week, the *Washington Post* reported that the President plans no immediate upgrade of NASA's budget or mission. The article went on to state that

the Administration intends to issue by early next year a blueprint for interplanetary human flight over the next 20 to 30 years. Can you comment on whether or not the Fiscal Year 2004 budget request should be revised given the grounding of the Shuttle fleet? Should the Shuttle be funded at the same level? NASA plans to release its Return-To-Flight Implementation Plan next week. I assume it will lay out what needs to be done prior to the next launch. Will NASA's plan also identify the required resources to implement that plan?

Answer. Until we can do a full analysis of the CAIB Requirements for Return to Flight, including an accounting of some of the design and production work that can be covered under existing continuing engineering contracts, the President's FY 2004 budget request for the Space Shuttle Program represents the most prudent funding level for the program. The Implementation Plan for Space Shuttle Return to Flight and Beyond identifies the engineering resources, but not costs, that will be required to respond to the CAIB Recommendations and to carry out those initiatives that we have identified that raise the bar above the CAIB Recommendations. As noted in the Implementation Plan, it will be updated, as our plans are refined. NASA will identify financial resources required as the specific implementation tasks are finalized.

Question 6. The General Accounting Office is expected to release its report on impacts of the *Columbia* accident to the Space Station later this month. Does NASA have any idea of what the costs of the delay would mean to the Station's budget?

Answer. NASA has been assessing the impacts of the *Columbia* accident on the ISS program since the accident occurred, and is now assessing the impacts of the NASA response to the CAIB recommendations on the ISS. To date, the Station program has estimated impacts in excess of $130 million starting in FY 2003. NASA expects the majority of the costs to be realized in FY 2004 and FY 2005. The estimates are based on a roughly one year slip in Station assembly and do not account for any additional logistics and assembly missions or the implementation of those CAIB recommendations that may affect the ISS. The estimates account for: delays in planned contractor de-staffing; contract equitable adjustments; the re-certification of flight hardware; replacement of the extended duration orbiter capability lost on Columbia; logistics carrier re-manifesting; spares and EVA tool replacement; and U.S. operations in Russia in support of crew rotation and Station resupply. A delay beyond one year, additional assembly and logistics missions, and CAIB implementation could drive ISS costs close to $200 million. But as stated above, all of the required assessments are still in work and a total cost impact cannot be provided now.

Question 7. Selection of NASA safety and quality personnel should be based upon meeting specific qualifications and possessing the right attitudes and disciplines for these critical positions. Certainly, the practice of assigning personnel to safety and quality as a part of an adverse personnel action must be stopped. Do you believe that those who have been re-assigned as a result of the *Columbia* accident do in fact meet such employment criteria?

Answer. No personnel have been assigned to safety and quality positions as a result of adverse personnel actions. The reassignment of any NASA employee is predicated on an analysis of the duties and performance requirements of the new position and a determination that the individual being reassigned has the ability and the experience necessary to perform the new duties and meet the new performance expectations. Performance expectations at the SES level include leadership and communications skills. As I have stated before, I have full confidence in the NASA team. Mobility across the Agency is a high priority to ensure that a variety of expertise and perspectives are applied to all areas of NASA activities, including safety. Recent reassignments to various positions at several NASA Centers reflect the selection of the best person for the job.

Question 8. Are any additional personnel changes forthcoming?

Answer. At this time, no additional personnel changes are planned that are related to the *Columbia* accident.

Question 9. Given the recent losses of vehicles over the past few years with other NASA programs, including the break-up of the *CONTOUR* spacecraft in August 2002 and the crash of the *Helios* solar electric airplane in June of this year, have you identified any similarities between these accidents?

Answer. Although specific details of these accidents and the NASA and contractor elements involved vary considerably, NASA has identified that some of the underlying causes are similar. These similarities include weaknesses in independent engineering oversight, inadequate analytical tools, and weak identification and follow-through on potential technical problems. As a result, NASA is also considering these other weaknesses and the associated lessons learned in evaluating how to apply the

recommendations, findings, and observations of the *Columbia* Accident Investigation Board's report to project management and engineering work throughout NASA.

Question 10. The Board has stated that NASA has not "institutionalized" its "lessons learned" approaches to ensure that knowledge gained from both good and bad experience is maintained in corporate memory. The Naval Reactors program and the Navy's Submarine Flooding Prevention and Recovery program have demonstrated the merits of an "institutionalized" program. While NASA has a lessons learned system, it is voluntary. Do you have any plans to more formally "institutionalize" NASA's "lessons learned" program?

Answer. Yes. NASA is conducting a major overhaul and consolidation of its various lessons learned systems to ensure they are timely, candid, relevant, trended, well promulgated, and properly incorporated in both training and design requirements. This overhaul had been initiated by NASA about two months before the *Columbia* accident, and is being further augmented to include the observations of the CAIB's report. The lessons learned systems upgrades are being based in large part on the Navy/NASA Benchmarking Study that has also focused on the high-quality systems of the Naval Reactors and SUBSAFE programs.

Question 11. Do you plan to apply any lessons learned from the *Columbia* accident to other areas of NASA? If so, where?

Answer. We will apply the lessons learned from the *Columbia* accident throughout NASA. In addition to the specific technical lessons, the organizational and cultural lessons are applicable to much of the other aspects of NASA work. Recognizing that one size does not fit all within NASA, we have formed a task group headed by the Goddard Space Flight Center Director to evaluate how best to apply all of the findings, observations, and recommendations of the Board's report to other NASA elements.

Question 12. The Board has recommended that NASA develop practical capabilities to inspect and effect emergency repairs to take advantage of the International Space Station, and to be used independently of the station. What are the technical requirements for implementing the CAIB recommendations and how soon can they be implemented?

Answer. NASA's near-term plan for risk mitigation calls for Space Shuttle vehicle modifications to eliminate the liberation of critical debris, and improved ground and Shuttle vehicle cameras for debris detection and damage assessment. On-orbit surveys of the vehicle's thermal protection system will be conducted using the Shuttle Remote Manipulator System and the Space Station Remote Manipulator System cameras, and ISS crew observations during Shuttle approach and docking. Techniques for repairing tile and Reinforced Carbon-Carbon by extravehicular activity are under development. The combination of these capabilities will help to ensure a low probability that critical damage will be sustained, while increasing the probability any damage that does occur can be detected and the consequences mitigated in flight.

NASA's long-term risk mitigation steps will refine and improve all elements of the near-term plan, ensuring an effective inspection and repair capability, not reliant upon the Space Station, is in place in time to support the next Hubble Space Telescope servicing mission.

Question 13. How will grounding of the Space Shuttle and NASA's "return to flight" efforts affect NASA's budget for Fiscal Year 2004? NASA has identified approximately $108 million in FY 2004 associated with implementation of an initial set of actions tied to the CAIB recommendations and other corrective actions, which are summarized in Enclosure #1.

Answer. Where applicable, hardware-related rough-order-of-magnitude (ROM) costs are primarily engineering estimates based on previous development and integration activities. Items also include nonrecurring ROM cost for studies, implementation and retrofit if appropriate, and include recurring ROM cost if required. In addition, ROM costs are included for engineering resources for certification and verification. We will be refining our estimates over the next few months, and we will keep the Committee informed as decisions are made.

Question 14. What effects will these efforts have on NASA's plans regarding the International Space Station?

Answer. NASA's post-*Columbia* strategy for the ISS will continue as planned. The ISS program will complete all ground development activities in accordance with its original schedules. Launch package testing and integration will be completed as planned so that the flight hardware is ready for Shuttle integration when launch dates are determined. Operations-related products will be developed to the degree practicable, then placed "on the shelf" until launch dates are defined. The Station

workforce will remain intact except for the contractor personnel no longer required for development activities or essential to assembly activities.

The ISS Continuing Flight Team (CFT) was chartered to review all CAIB results for applicability to the ISS Program. This team will ensure that all necessary steps are taken to apply the lessons learned from the *Columbia* accident to the ongoing operation of the ISS. Representatives from all NASA field centers supporting human space flight, as well the Astronaut and Safety and Mission Assurance offices, are members of the team. NASA will continue to work closely with its International Partners and keep the lines of communication open as NASA implements process improvements and enhancements as a result of lessons learned from Columbia. The first edition of NASA's Implementation Plan for International Space Station (ISS) Continuing Flight has been provided to Congress.

NASA is also assessing the financial and workforce impacts of the implementation of the CAIB recommendations on the ISS program, and will adjust workforce allocations and budget to accommodate all required changes to the program. NASA intends to re-baseline the ISS program during next year's budget formulation cycle.

Question 15. One of the issues of greatest concern to me is the fact that there were three requests for on-orbit imaging of *Columbia,* and that Shuttle management turned down these requests. What steps do you intend to take to ensure that similar requests are not ignored in the future?

Answer. NASA has concluded a Memorandum of Agreement with the National Imagery and Mapping Agency that provides for on-orbit assessment of the condition of each Orbiter vehicle as a standard requirement on every flight. In addition, NASA is putting in place standard operating procedures to implement this, and any other relevant agreements. Also, in order to improve the technical and cultural capabilities for the Mission Management Teams (MMT) responsible for Space Shuttle flight operations, NASA will conduct regular MMT simulations with realistic in-flight crises, engage independent internal and external consultants that will address the management, cultural, and communications issues raised in the CAIB report, and continue benchmarking best practices from other high-risk organizations.

Question 16. What recommendations can you offer Congress to help formulate the future of the human space flight program?

Answer. The Administration is currently working through an interagency process to formulate future space exploration objectives, including those for the human space flight program. Following the conclusion of the process, the Administration plans to work closely with Congress on the development and implementation of plans for the future of the human space flight program.

ATTACHMENT

ENCLOSURE 1

*Return to Flight Estimated Costs and Implementation Plan Map for those items started in FY 2003

($ millions)

	FY 03**	FY 04	FY 05	FY 06	FY 07	FY 08	FY 09	Total	***Recommendation #'s Map to Implementation Plan									
	41.1	106.5	73.0	23.0	11.0	12.0	12.0	278.6	CAIB #3.2-1	CAIB #3.3-1	CAIB #3.3-3	CAIB #3.3-4	CAIB #3.4-1	CAIB #3.4-2	CAIB #3.4-3	CAIB #4.2-1	CAIB #4.2-3	CAIB #6.4-1
RTF Projects IMPLEMENTED in FY 2003																		
Orbiter RCC Inspection & Modification	31.4	20.6	10.0					62.0	O									O
On-orbit TPS Inspection & EVA Tile Repair	5.1	33.9	41.0	10.0				90.0										O
External Tank Ramp Camera, Bipod Ramp Heater	24.3	49.7	15.0	9.0	9.0	10.0	10.0	127.0	O				O	O	O	O	O	O
SRB Items (ETA Bolt Catcher, Ring Invest., Camera)	3.9	7.0	3.0	3.0	2.0	1.0	1.0	20.9						O	O	O		
Orbiter Systems Improvements (SSME HPOTP, Avionics)	7.9	7.5	6.0	1.0				22.4		O	O	O						
Program Integration	0.5	1.5						2.0										
Total SSP RTF Related	41.6 (1)	108.0 (2)	73.0	23.0	11.0	12.0	12.0	280.6	O = Open					C = Complete				

(1) The $42M for FY 2003 RTF is an update to the estimate included in NASA's Septebmer 4, 2003, FY 2003 Operating Plan submittal. These numbers do not include any reserves.

(2) The $108M for FY 2004 represents an update to the items which have moved into implementation. These numbers do not include any reserves.

Additional Notes:

*These estimates could change due to improved estimates, including reserves, additional tasks and added scope as we better understand the implementation of RTF recommendations.

**The revised FY 2003 numbers will be included in an update to NASA's September 4, 2003 Operating Plan submittal.

***This is a subset of current items being addressed at this time; all RTF recommendations will eventually be addressed, although each item my not require funding.

RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY HON. OLYMPIA J. SNOWE TO HON. SEAN O'KEEFE

From the report, I understand that after the first accident, investigators found that at the Marshall Space Flight Center, for example, managers tended toward "management isolation." I also note from the report—and this is not new, but in now looking at these issues in their totality—that separate responsibilities for different shuttle systems and production are located at different geographical "centers" around the country.

Finally, I note in the report that Daniel Goldin implemented at NASA the management notion that a corporate headquarters should not exert bureaucratic control over a complex organization, but rather set strategic directions and provide operating units with the authority and resources needed to pursue these directions. Another principle was that checks and balances were unnecessary and some times counterproductive, and those carrying out the work should bear primary responsibility for its quality.

Question 1. Mr. O'Keefe, do you believe, that even after the first accident, the destruction of the *Challenger,* and the subsequent changes at NASA that there was "management isolation" at the various centers? And do you agree with the management philosophies I just outlined from Dan Goldin?

Answer. During my tenure at NASA, I have not seen evidence of "management isolation" as described in the report by the Rogers Commission. Also, I cannot speak to Dan Goldin's management principles or the direction his team pursued during his ten-year tenure. His team was working under a different Administration with different guidelines. Under today's circumstances and my management philosophy, there will be checks and balances throughout the Agency, and NASA Headquarters will be more involved in all Programs.

Question 2. Do you believe that there should be a different management standard for NASA, given its unique role in general, and within the government specifically, and given the inherently risky nature of its mission for human life? In other words, should NASA reach for a different standard than, say, the management structure of an International Widget corporation, or is good management practice just good management practice?

Answer. Good management is good management. Implementation of various management practices should be tailored for various industries. The U.S. Government as a whole has a special responsibility as the steward of the public trust, to maintain the highest standards of management excellence. To that end, NASA is currently working with other high-risk entities, such as the Navy submarine safety programs, to benchmark their best practices and incorporate these experiences into NASA's programs.

Question 3. According to the report, after two close calls in July 1999 with STS–93, former Administrator Dan Goldin chaired a Shuttle Independent Assessment Team (SIAT). Among the findings of the team was that, "The SIAT was concerned with "success-engendered safety optimism. The Space Shuttle Program (SSP) must rigorously guard against the tendency to accept risk solely because of prior success."

Mr. O'Keefe, can you tell me in the wake of that assessment, to your knowledge, specifically what steps or mechanisms, if any, were in place to answer that criticism? And, if there were mechanisms that were put in place, how did they hold up with regard to what happened with *Columbia,* and particularly with the numerous requests for satellite imaging, as well as the assessments of the foam strikes?

Answer. Based on the SIAT final report, NASA concluded that most of SIAT's recommendations were aimed at bringing best practices from other high-risk organizations into the Space Shuttle program (SSP). Prior to my arrival at NASA, the Space Shuttle program had begun a series of regular senior management meetings that specifically addressed the issue of complacency and the inherent risk to the SSP relative to process and procedure change. After I became NASA Administrator in 2002, this review process was expanded to include of best practices from the Navy submarine safety programs and working to incorporate this experience into all of NASA's programs, including the Space Shuttle program.

NASA, and especially the Space Shuttle program have had mechanisms in place that allow employees to submit safety concerns to safety and program management. Since the *Columbia* Accident and the subsequent *Columbia* Accident Investigation Board recommendations, additional measures are being taken to improve and streamline this reporting process. Initial management changes have been put into place, such as the establishment of a new independent NASA Engineering and Safety Center, initiation of Mission Management Team training and simulations, and a

reorganization of the Space Shuttle program to include stronger systems integration.

Question 4. That same SIAT report also found that communication problems and concerns upward to the Space Shuttle Program from the "floor" also appeared to "leave room for improvement." Mr. O'Keefe, was this warning heeded within NASA—if so, what kind of priority was the concern given and then looking forward, how do you ensure that, if changes are made, the impact of those changes are being *assessed,* and that the changes don't fall by the wayside? Because I believe that will largely dictate how NASA functions in the future, and the future safety of the Shuttle Program.

Answer. As stated in the response to the above question, a number of different actions have been taken to further enable communication from both the "top-down and bottom-up" within NASA. The Agency will take additional actions in the future as we work with representatives from industry, academia, and other government organizations to determine how best to institutionalize "best practices" into the NASA culture, with clear communications being a high priority area for improvement.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. FRANK R. LAUTENBERG TO HON. SEAN O'KEEFE

Question 1. Admiral Gehman, in your view, what role did NASA's relationship with contractors have in the breakdown in communication that led to the organizational failures you discuss in the Board's report? If NASA was performing all of the contracted work rather than its contractors, would these communication breakdowns have been as likely?

Answer. Since the earliest days of its human spaceflight program, NASA has relied upon the expertise of the Nation's aerospace contractors to carry out its programs. The CAIB noted that there were communications problems within the Space Shuttle program as a whole, both within the government and, to a lesser extent, between the government and its contractors. In response to these findings, NASA is taking steps to improve its own internal communications and to enhance the ability of the Space Shuttle program to provide insight into contractor operations.

Question 2. "Mr. O'Keefe, the Kraft report of March 1995 found that " many inefficiencies and difficulties in the current Shuttle Program can be attributed to the diffuse and fragmented NASA and contractor structure. Numerous contractors exist supporting various program elements, resulting in ambiguous lines of communication and diffused responsibilities." What actions did NASA take to address this concern in the Kraft report?"

Answer. The Kraft report was the product of a team of government, aerospace industry, and former NASA leaders, formed by NASA Administrator in November 1994, to review Shuttle operation management and "propose innovative approaches to decrease total operating costs while maintaining systems safety." The report stated the Shuttle program should:

- Establish a clear set of program goals with greater emphasis on cost-efficiency and "user-friendly" payload integration.
- Redefine management structure, separating development and operations and disengaging NASA from daily operation of the Shuttle.
- Change environment in the Program to pursue these goals.

The report concluded the best approach was to consolidate operations under a single-business entity. A NASA-Prime Contractor program structure was proposed to separate development vs. operational activities, minimize NASA-contractor interfaces, eliminate overlapping tasks, and strengthen responsibility for operations and motivation to reduce costs. NASA would define clear Shuttle operations requirements with limited oversight. This change allows the contractor to perform day-to-day operations, increasing the content and scope of work being performed by the private sector. The government would still retain all Shuttle mission execution responsibilities. Regular and independent review of program restructuring process is done to ensure safety.

On November 30, 1995, the NASA Administrator established a single contract, the Space Flight Operations Contract (SFOC), "to consolidate all mature operational areas of the Shuttle program." NASA recommended awarding the SFOC to the United Space Alliance (USA), a joint venture of Rockwell International (now the Boeing Company) and Lockheed Martin Corporation. This decision was based on NASA's commitment to launch the International Space Station on schedule, and to

maintain safety. The SFOC contract was initiated in October 1996. To date, twenty-one separate Space Shuttle contracts of the have been consolidated into SFOC.

Since the *Columbia* accident and at the recommendation of the Columbia Accident Investigation Board, the Space Shuttle Integration Office has been reorganized. The integration function has been strengthened and elevated to a higher level in the Space Shuttle program organization to make it capable of integrating all of the Shuttle program elements including those performed by the contractor community. It also has been given the authority and accountability for the integration function.

Question 3. I believe that there is an inherent conflict of interest between profit and the level of funding spent on safety. The Space Flight Operations Contract rewards cost reductions to the contractor, United Space Alliance. But doesn't this create a culture of creating "minimum safety requirements" or "safety on the cheap"? Outside of costly government oversight, which could obviate any savings, is this type of an economic performance-based contract ideal in for safety-critical programs like the space shuttle?

Answer. To be a good steward of the Government's funds, NASA must manage each of our contracts efficiently and effectively. Like other NASA contracts, safety is a critical factor in the rating of performance under the Shuttle Flight Operations Contract (SFOC). Safety is used as a key factor in the award fee earnings determination for SFOC and is the only individual factor for which the contractor receives a separate specific score every six months. It carries a significant weight and serves as a "gate" for the contractor's ability to reap their share of any cost savings. In order to pass this "gate", the contractor must achieve a safety evaluation factor rating, which, at a minimum, reflects effective performance; accomplishment of requirements in a timely and efficient manner; and work which substantially exceeds minimum contract requirements. This "gate" feature is used under the contract to deter any motivation by the contractor for taking a "minimal" approach to safety in order to increase cost reduction. It serves to emphasize the importance of safety and the need to achieve much more than the "minimum" safety requirements. Regarding the use of a performance-based contract for the SFOC, we feel it has been and can continue to be effective for management of Shuttle operations. Notwithstanding that, we had commenced a review of the contract terms and alternate approaches to the current contract structure prior to the *Columbia* accident in order to effect improvements. We are currently assessing any additional changes that may be necessary as a result of the CAIB Report, and plan to renegotiate the contract terms in the near future to reflect the current NASA priorities and CAIB recommendations.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JOHN MCCAIN TO HAROLD W. GEHMAN, JR.

Question 1. The report indicates that three different requests were made for on-orbit imaging of the *Columbia,* and makes it clear that the Debris Assessment Team felt that it needed these images to analyze the effect of the foam strike. Why did the Shuttle management reject these requests?

Answer. Shuttle managers firmly believed that foam could not damage the RCC panels. They therefore characterized the request for pictures as a superfluous request to prove that the shuttle condition was safe. Since managers "knew" the shuttle was safe, they wanted engineers to "prove" it was unsafe before they went to the effort to request national level imagery. Since the engineers needed images to determine the extent of damage, they were unable to "prove" the condition of the shuttle was unsafe. Second, NASA managers assumed they knew the capabilities of national level imagery and that national level imagery could not detect damage on the shuttle, despite the fact few of them were familiar with imagery capabilities or even had the security clearances to know what capabilities were available. Third, there was confusion about the source of the imagery request. An informal request for imagery originated on Flight Day Two at Kennedy Space Center outside of normal request channels. KSC members, realizing they had not followed proper protocols, terminated actions taken to that point requesting imagery. A subsequent formal request for imagery from the Debris Assessment Team was mistakenly interpreted by the MMT as the same informal request from KSC. The MMT claimed to never have been aware of a formal request for imagery from the Debris Assessment Team. Their belief that foam could not damage RCC, the engineers' lack of proof that the shuttle condition was unsafe, confusion as to the source of the request, and their erroneous assumptions regarding national level imagery capabilities, led Linda Ham to cancel the requests for imagery.

Question 1a. What recommendations did the Board make to ensure that similar requests are not ignored in the future?

Answer. First, the CAIB eliminated the issue by requiring an on-orbit inspection of the orbiter on each flight soon after orbit insertion. The Board made significant recommendations regarding the need to change the safety culture. Second, the Board directed NASA to update its process for requesting photos of the orbiter while on orbit. Third, the Board directed NASA to place additional cameras on each orbiter to better determine when damage exists. Fourth, the Board directed NASA to improve the quality of orbiter imagery during launch and ascent. All of these will directly contribute to ensuring that engineers have the best imagery data available during any similar future situations.

Question 2. Question 2 should be answered by NASA.

Question 3. Your report states that based on NASA's history of ignoring external recommendations, or making improvements that atrophy with time, the Board has no confidence that the Space Shuttle can be safely operated for more than few years based solely on renewed post-accident vigilance.

(a) Do you expect that all of the CAIB's recommendations, not only the "return to flight" ones, will be implemented by NASA? Do you believe that the NASA task force created to assess NASA's implementation of the CAIB recommendations is the correct approach?

Answer. The Board believes that Congress, the Administration and NASA will determine what recommendations, and to what extent those recommendations, will be implemented. The Board did not prioritize and believes all the recommendations should be implemented and all the significant issues addressed in Chapter 10 should be addressed by NASA because they fall into the category of "weak signals" that could be indications of future problems.

(b) What are the limiting factors affecting the safe operation of the Shuttle beyond more than a few years?

Answer. As the Shuttle System ages, new and sometimes unpredictable reliability issues will arise. Since these issues are unpredictable, they must be dealt with as they come up. The present management system does not do that well. To quote from the report:

> "Based on NASA's history of ignoring external recommendations and making improvements that atrophy over time, the Board has no confidence that the Space Shuttle can be safely operated for more than a few years based solely on renewed post accident vigilance. The Board felt the Management system is inherently unsafe beyond the short-term. Complex systems almost always fail in complex ways and the Board is convinced that NASA can fly again in the near-term if the RTF recommendations are followed. However, NASA needs to look into the organizational and cultural aspects to lessen the chance another accident will occur beyond more than a few years. Additionally, the Shuttle is an aging spacecraft in a research and development era requiring special attention to orbiter corrosion, orbiter maintenance down periods/major modification, test equipment, etc. The Board has serious concerns how NASA can manage an aging shuttle life cycle with a lack of an integrated hazard analysis system."

NASA needs to be resourced to effect change recommended by the CAIB report . . . many of the organizational recommendations retract previous management efficiencies in favor of a new, more balanced system of checks and balances which will increase budget and manpower demands. These organizational changes are necessary to improve the safety culture and create an atmosphere of high reliability.

Question 4. The report speaks of a "broken safety culture" at NASA. Can you elaborate on this for the Committee?

Answer. Safety culture refers to an organization's characteristics and attitudes—promoted by its leaders and internalized by its members—that serve to make safety the top priority.) In this context, the Board believes the mistakes that were made on STS–107 are not isolated failures, but are indicative of systemic flaws that existed prior to the accident.

The investigation revealed that in most cases, the Human Space Flight Program is extremely aggressive in reducing threats to safety. But we also know—in hindsight—that detection of the dangers posed by foam was impeded by "blind spots" in NASA's safety culture. The investigation uncovered a troubling pattern in which Shuttle Program management made erroneous assumptions about the robustness of a system based on prior success rather than on dependable engineering data and rigorous testing.

Further, the Shuttle Program's complex structure erected barriers to effective communication and its safety culture no longer asks enough hard questions about

risk. (Had the Shuttle Program observed insight from High Reliability, Normal Accident and Organizational Theory, reviewed Best Safety Practices and learned from its own history, the threat that foam posed to the Orbiter, particularly after the STS–112 and STS–107 foam strikes, might have been more fully appreciated by Shuttle Program management. Evidence of the broken safety culture is seen in the "prove it's unsafe" approach to the foam strike. This attitude by management kept them from seeing the need to conduct serious contingency planning on whether or not the Shuttle was in trouble and how to save it either by on-orbit repair or rescue. Every problem was simplified and reduced to the least threatening posture that truncated management's entire thought and decision processes.

Question 5. The Board recommends preparing a detailed plan for creating an independent Technical Engineering Authority, independent safety program, and reorganized Space Shuttle Integration Office. Why is it necessary to complete the plan for these operations, as opposed to implementing the operations themselves, before the shuttle returns to flight?

Answer. The recommendations to create a technical engineering authority, a truly independent safety organization and an effective SSP program integration office are designed to prevent the gradual return to bad habits that normally occurs at all large organizations as the memory of a tragic accident fades. As noted in the Report, the Board is confident the next half dozen flights will receive all the vigilance and oversight possible. Several Board members have extensive experience managing large organizations and know with some personal knowledge that the kinds of changes represented by these recommendations are fundamental, complex and challenging to implement. These three recommendations are changes in FUNCTIONS, not just wiring diagram changes and they will take considerable time to implement. Therefore, getting the plan written and submitted in a timely manner is important and the actual implementation should be done thoughtfully and carefully.

Question 6. The Board recommends establishing an independent Technical Engineering Authority that is responsible for technical requirements, and all waivers to them, that will build a disciplined approach to identifying, analyzing, and controlling hazards throughout the life cycle of the Shuttle System. How should this new authority be designed and staffed to prevent some of NASA's bad habits, such as the reliance on past successes as a substitute for sound engineering practices, from leaching into this new organization?

Answer. The Board intentionally declined to tell NASA how to specifically structure this new organization.

Question 7. The Board recommends that NASA Headquarters Office of Safety and Mission Assurance should have direct line authority over the entire Space Shuttle Program safety organization and should be independently resourced. The Rogers Commission made a similar recommendation.

(a) Why is it important that the Office of Safety and Mission Assurance has direct line authority over the Space Shuttle program and be independently resourced?

Answer. The question should state "Why is it important that the Office of Safety and Mission Assurance have direct line authority over the Space Shuttle *safety* program and be independently resourced?" The Board did not recommend that the Safety office have direct line authority over the entire SSP.

In order for a safety system to be effective and for people within the organization to feel comfortable using it, it must operate outside, but in parallel with the normal management chain of command; it must be equal in stature to the organization it monitors; it must have visibility into all levels of the organization; it must report directly to the senior leader in charge of the overall organization; and, it must have its own line item budget. Each of these is explained below.

Safety must operate outside the normal management chain of command. If we expect people to report problems, they must feel secure within the organization to do that. If they feel threatened, a safety program operated outside the normal chain of command, allows them an avenue to raise a safety concern without feeling like they are jeopardizing their livelihood. In the case of the shuttle program, the safety organization was controlled by the SSP, so the program dealt with safety concerns about the program. This structure allowed the shuttle program manager to unilaterally waive technical requirements (such as the debris prevention requirement). An independent technical authority or safety function would ensure technical requirements are met or resolved before subsequent launches. Engineers stopped viewing the safety office as a reporting option since their complaints basically went right back to the program, leaving them vulnerable to retribution from management.

Safety must be equal in stature to the organization it monitors. Safety programs must have a status that can stand up to the program it monitors. It does this by having a sufficient budget, high-quality safety professionals who are respected by

their peers and a link to senior leadership to give them relevance. If safety is not of equal stature, the safety program will be ignored.

Safety must have visibility into all levels of the organization. No area of any program within an organization can be exempt from review and monitoring by the safety office. Without visibility and authority to challenge at all levels of the organization, the safety program will not be effective.

Safety must report directly to the senior leader in charge of the overall organization. Safety gives the senior leadership of an organization a different perspective on problems and solutions. If it is not directly reporting to the senior leadership, then the programs view it as a less important function within the organization. Safety must also have the authority to stop an operation for safety reasons and that authority can only come from senior leadership. Finally, to have relevance at all levels of an organization, safety must be directly reporting to the senior leadership.

Safety must have its own line item budget. Safety programs need great people and they need sound budgets. If they must rely on the program or other parts of the organization to fund their activities, they will never be relevant and will always be limited in effectiveness. Owning their own budget empowers all the other concepts discussed above and gives the safety office the autonomy it needs to be highly effective. The safety budget should not compete with space shuttle program funds.

(b) Why has NASA been so resistant to this recommendation?

Answer. Good safety programs cost good money and require good people in order to be effective. Shuttle program managers believed they were always being safe so a robust safety program didn't add value to what they were doing. If it didn't add value, then why fund it? Since the SSP owned its own safety budget, they could decide how much safety they wanted to buy. As budgets became constrained, the safety budget was continuously cut to make up funds. In fact, most of safety was matrixed from other areas of NASA or contracted out.

Question 8. Since October 1996, Space Shuttle operations have been managed by the United Space Alliance.

(a) Could you please explain how contracting out Space Shuttle operations have affected NASA's in-house engineering capabilities?

Answer. Over the years, NASA, in efforts to reduce government head count and operate more efficiently, assigned more work and responsibility to contractors and relied more heavily on contract financial incentives, as opposed to direct Government oversight. The result is that NASA technical expertise has winnowed down to the point that NASA no longer always has the sophisticated and elegant system of oversight by very knowledgeable people that such a complex enterprise requires. The Board is also concerned that functions have been shifted to contractors that should be performed by Government personnel, resulting in the shift of technical expertise from the Government to the private sector.

(b) The report states that the Space Shuttle should be considered a developmental vehicle, not an operational one. How would this change of status effect NASA's requirements for the United Space Alliance contract?

Answer. The differences between how a developmental vehicle is managed vs. how an operational vehicle is managed are profound. NASA management repeatedly stated that the Shuttle is officially considered a developmental vehicle, however the Board found ample evidence to conclude the Shuttle was being employed in an operational manner. The Board found no evidence to suggest that the contract had anything to do with this accident, but did find procedures that should be carefully reviewed prior to the next contract solicitation.

The most significant issue that concerned the Board was the extensive management functions that are included in the contract. While there is nothing wrong with this as a policy, the practical result is a migration of technical expertise from the government sector to the private sector. It is our opinion that NASA is best suited to answer any questions regarding changes in requirements of the USA contract. However, anytime a government owned developmental vehicle is being flown a requirement exists for significant government oversight. Whether the shuttle is developmental or operational affects the overall management approach to flying the shuttle. It would call for a more distinct line of separation between government and contractor and require retention of a greater level of technical expertise by the government in order to be more deeply involved at the subsystem level. It is also the Board's opinion that were the *Columbia* viewed as developmental, procedures may have been in place to more exhaustively seek out the extent of damage to the left wing leading edge instead of continuing the "operational" 16-day science timeline.

(c) Could you please discuss the Board's findings regarding relations between NASA and United Space Alliance as they worked to determine the damage done to *Columbia* by the foam debris strike? OK

Answer. The report describes this relationship on page 142. After United Space Alliance became contractually responsible for most aspects of Shuttle operations, NASA developed procedures to ensure that its own engineering expertise was coordinated with that of contractors for any "out-of-family" issue. In the case of the foam strike on STS–107, which was classified as out-of-family, clearly defined written guidance led United Space Alliance technical managers to liaise with their NASA counterparts. Once NASA managers were officially notified of the foam strike classification, and NASA engineers joined their contractor peers in an early analysis, the resultant group should, according to standing procedures, become a Mission Evaluation Room Tiger Team. Tiger Teams have clearly defined roles and responsibilities. Instead, the group of analysts came to be called a Debris Assessment Team. While they were the right group of engineers working the problem at the right time, by not being classified as a Tiger Team, they did not fall under the Shuttle Program procedures described in Tiger Team checklists, and as a result were not "owned" or led by Shuttle Program managers. This left the Debris Assessment Team in a kind of organizational limbo, with no guidance except the date by which Program managers expected to hear their results: January 24. Had this Tiger Team authority issue been clarified, the Debris Assessment Team would not have taken "no" for an answer in response to their request for imagery. They would have demanded imagery as a necessary requirement to be able to do their damage assessment and used the shuttle program as their authority.

Question 9. NASA is currently developing an Orbital Space Plane to transport astronauts to the International Space Station. Based on your analysis of the development of the Space Shuttle and the lessons learned, what actions should be taken in developing the new Orbital Space Plane?

Answer. The most important step we can take in designing the next orbital vehicle is to agree on a national vision on what we want the manned space program to accomplish. This would lead to the development of a concept of operations followed by a set of requirements for the vehicle to meet the objectives of a vision. The concept of operations and the requirements would then drive the design of the new orbital vehicle. Without an agreed national vision, the next orbital vehicle will fall victim to the same set of design compromises that plague the current orbiter fleet and the previous failed attempts to implement a replacement for the Space Shuttle.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. FRANK R. LAUTENBERG TO HAROLD W. GEHMAN, JR.

Thank you for your continued dedication and support of the *Columbia* Investigation, and for your thoughtful questions for the record. I hope that you will find the following responses to be satisfactory.

Question 1. Role played by "NASA's relationship with contractors" in the "breakdown in communication that led to the organizational failures."

Answer. Over the years, NASA, in efforts to reduce government head count and operate more efficiently, assigned more work and responsibility to contractors and relied more heavily on contract financial incentives, as opposed to direct Government oversight. The result is that NASA technical expertise has winnowed down to the point that NASA no longer always has the sophisticated and elegant system of oversight by very knowledgeable people that such a complex enterprise requires. The Board is also concerned that functions have been shifted to contractors that should be performed by Government personnel, resulting in the shift of technical expertise from the Government to the private sector.

Question 2. If NASA was performing all functions, would these communications breakdown have been as likely?

Answer. Yes, the communications problems occurred where they always occurr, at the interfaces between offices and functions. Those interfaces exist in purely governmental organizations as well as contractor organizations. Once again, the only issue the Board was concerned about was the migration of technical expertise that went with the migration of oversight positions to the private sector.

Question 3. Is there an inherent conflict of interest between profit and safety?

Answer. Not in the sense that one can infer the level of safety by the level of profits. However, in this business, careful attention to technical detail, not profit levels, should be the principal focus for managers and workers, both government and contractors alike.

The Board found no evidence that profit considerations contributed to the accident or compromised safety. However, the elaborate, multiple profit incentives NASA has adopted in efforts to promote contractor efficiency and performance, risks making

technical considerations secondary to profit considerations among managers and workers. Where emphasis should be on determining what is the right thing to do technically, knowing that company profits are directly at risk, can encourage "good news reporting" and make it more difficult for management and workers to surface problems that could delay schedules or otherwise adversely affect profit.