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# SPACE SHUTTLE COLUMBIA INVESTIGATION

## HEARING

BEFORE THE

## COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

MAY 14, 2003

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COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

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# CONTENTS


| | Page |
|---|---|
| Hearing held on May 14, 2003 | 1 |
| Statement of Senator Allen | 5 |
| Statement of Senator Breaux | 6 |
| Prepared statement | 6 |
| Statement of Senator Brownback | 32 |
| Statement of Senator Hollings | 2 |
| Prepared statement | 3 |
| Statement of Senator McCain | 1 |
| Statement of Senator Nelson | 37 |
| Statement of Senator Snowe | 26 |
| Prepared statement | 29 |
| Statement of Senator Sununu | 3 |
| Statement of Senator Wyden | 3 |
| Prepared statement | 4 |

WITNESSES

| | |
|---|---|
| Gehman, Jr., Admiral Harold W., Chairman, Columbia Accident Investigation Board | 11 |
| Prepared statement | 13 |
| O'Keefe, Hon. Sean, Administrator, National Aeronautics and Space Administration | 7 |
| Prepared statement | 9 |

APPENDIX

| | |
|---|---|
| Response to written questions submitted by Hon. John McCain to: | |
| Hon. Sean O'Keefe | 51 |
| Admiral Harold W. Gehman, Jr. | 55 |
| Response to written questions submitted by Hon. Bill Nelson to Hon. Sean O'Keefe | 55 |

# SPACE SHUTTLE COLUMBIA INVESTIGATION

**WEDNESDAY, MAY 14, 2003**

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

The Committee met, pursuant to notice, at 9:33 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. Today's hearing is the second in a series of hearings to examine the causes of the Space Shuttle *Columbia* accident. I welcome Administrator O'Keefe and Admiral Gehman and look forward to hearing from them on the status of the investigation, including the *Columbia* Accident Investigation Board's most recent recommendations and NASA's plan to return the Space Shuttle flight program.

It is extremely important that Congressional Oversight Committees have access to all critical information in this investigation, and I want to fully impress that fact on our witnesses. I repeat, it is extremely important that Congressional Oversight Committees have access to all critical information in this investigation.

In addition to the *Columbia* accident, we will also discuss NASA funding concerns. I am greatly troubled over the increasing pattern of congressional earmarking, and we may learn that the funding directives to Members' priority projects at the expense of NASA's own funding priorities have led to grave consequences.

Congressional earmarking of NASA funding increased from $24.7 million for Fiscal Year 1998 to $167 million in Fiscal Year 2003, a 576 percent increase in NASA earmarks. Examples of such earmarking which have prevented NASA from allocating funding to programs that it considered to be most critical include $15.5 million for the Institute for Scientific Research in Fairmont, West Virginia, $7.6 million for hydrogen research being conducted by the Florida State University System, $2.25 million for the Life Sciences Building at Brown University, Providence, Rhode Island, $1.8 million for the construction of a Gulf of Maine Laboratory at the Gulf of Maine Aquarium Foundation, and $1.35 million for expansion of the Earth Science Hall at the Maryland Science Center in Baltimore, Maryland. These are just a few of the egregious earmarks that have little or nothing to do with NASA, or certainly its core mission.

While the level of congressional earmarks has grown, NASA's overall budget has remained relatively stable. As a result, NASA has been forced to do more with less money while facing deteriorating infrastructure and safety concerns. I would like to hear from Administrator O'Keefe and Admiral Gehman and learn their views on how this pork-barrel spending may have affected NASA operations, including the Space Shuttle Program.

In addition, I am concerned that it appears that NASA tries to curry favor with a broad base of members by trying to ensure that programs affect as many states as possible, even when this may not be the most effective or productive use of resources. Even more remarkable is when NASA funds a $900,000 Computing Information and Communications Program for mobile, wireless, and broadband Internet capability that had been, according to NASA's Fiscal Year 2003 operations plan, quote, "inadvertently dropped as an earmark," unquote, from the 2003 Omnibus Appropriations Conference Report. I urge the Administrator to conduct a thorough review of all NASA's funding plans to ensure they are oriented to meet the legitimate needs of NASA's missions.

Other important issues that need to be examined today include NASA's culture and the concerns of NASA employees about *Columbia's* safety, the National Imagery and Mapping Agency and why it was not used to take on on-orbit images of the *Columbia*—we have heard conflicting stories on that particular aspect of the *Columbia's* tragedy, and we would hope that will be cleared up; the impact of the *Columbia* accident on the construction of the International Space Station; the safety of the Soyuz, which is currently the only transport to and from the Space Station; and congressional access to privileged information from the CAIB investigation.

I look forward to an informative hearing this morning and, again, thank the witnesses for appearing today.

Senator Hollings?

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

Senator HOLLINGS. Well, thank you, Mr. Chairman. I will just file my prepared statement, with only this comment.

The distinguished Chairman has just allowed that we at the congressional level expect to receive all statements and all materials. The Chairman more or less gives that command like he is still in the Navy, but that is not what has happened. As I understand, from the news reports, you have given confidentiality to those giving statements to make darn sure that the Congress does not receive all materials of the investigation.

So point one, I am disturbed about the investigation itself, because we went through with this with *Challenger*. This accident looks like the same act, same scene, with no regard for safety for the *Columbia*. I will just leave it at that, and we will have some questions.

[The prepared statement of Senator Hollings follows:]

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

On February 1, America lost seven heroes. Today, the Committee, our witnesses, and NASA have the responsibility to learn from this tragedy so that we will not repeat the mistakes that led to this accident.

Mr. Chairman, those of us who have been on this Committee for many years are experiencing a sense of deja vu. Some of the problems highlighted by the *Challenger* accident are eerily present again. It seems that some of the lessons that we learned about quantifying risk and evaluating near-misses were learned and then forgotten in the ensuing years.

For example, since the first Shuttle flights more than 20 years ago, pieces of the external tank's insulating foam have come off during ascent to orbit many times. But the Shuttle's tiles and reinforced carbon-carbon were not designed to absorb debris hits. NASA engineers issued waivers, then tried to eliminate foam shedding; but never fully succeeded. Last October, *Atlantis* shed a much larger piece than normal which struck the solid rocket booster. Yet, two flights later, not a single mention of foam trouble was made in *Columbia's* "flight readiness review," the vigorous pre-flight discussion of safety issues.

While there is no question that we will continue to send humans to space, we must put everything else on the table. Today we begin at square one—how and why did the *Columbia* Accident happen and what does it mean? How does NASA deal with problems, including seemingly innocuous ones such as foam shedding that have such tragic consequences? What are the demands of space flight, and is NASA as an agency, or are we as a nation prepared to step up to them?

We are not asking questions like these to find blame nor to wander from the path that the heroes of Mercury, Gemini, and Apollo laid out before us. Rather, we want this hearing to begin to inform the larger questions that the Committee will need to address after Admiral Gehman and his colleagues have finished their report.

How do we go about fulfilling the charter that John F. Kennedy originally laid out for us, to do these things because they are hard, not easy. For too long, we have avoided dealing with the hard questions about the future of space. We want today's hearing to begin take us to a place from where we can see our way forward into space, not backward, perhaps more clearly than we have ever seen this distance before.

Thank you Mr. O'Keefe and Admiral Gehman for being with us today.

The CHAIRMAN. Thank you, sir.

Senator Sununu?

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

Senator SUNUNU. Thank you, Mr. Chairman.

Welcome, Administrator O'Keefe and Admiral Gehman. I am looking forward to the testimony. I know there has been a tremendous amount of work done, and I think, at the very least, we owe a great deal of thanks to all of the personnel that have been on the ground, volunteers—I mean, literally thousands of them working hours and hours and hours to make sure that, to the best of our ability, we have as much material as possible to draw sound conclusions from through the investigation. So welcome, and I look forward to your testimony.

The CHAIRMAN. Senator Wyden?

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

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

I, too, want to welcome our witnesses and thank them for their cooperation. There are a number of areas I want to explore this morning. One involves the preliminary recommendations that have been received from the Accident Investigation Board. There are two preliminary recommendations, one calls for the comprehensive in-

spection plan to determine the structural integrity of the reinforced carbon-carbon system components, and the second is to modify NASA's agreement with the National Imagery and Mapping Agency to use satellites to make on-orbit imaging for each Shuttle flight a standard requirement.

When I learned about these two recommendations, and I recognize these are both, preliminary recommendations, what really struck me is, "Why were these recommendations not put in place prior to the tragedy?" I think this would be an area that I would want to explore with you, Administrator O'Keefe, because you just say to yourself, it seems really tragic that current inspection techniques are not adequate to assess the structural integrity of the reinforced carbon-carbon supporting structure and attaching hardware. And I think my questions in this area would be twofold. One, why was it not done before the tragedy? And second, what is being done currently to implement the recommendations?

The other area, Mr. Chairman, that I want to look at is this question of the way technical analyses are used by the agency. Of course, the concern here, as has been reported widely in the press, is that NASA managers refused to seek the photographs of the damaged Shuttle, and the engineers were making pleas that it be done so. I recognize this deals with the memorandum that you all sent to the Committee, but I think I would like to explore this some more, and I will be asking about that, Administrator O'Keefe.

Mr. Chairman, I am glad you are doing this. To me, there really is not anything more important than the oversight function of the United States Congress, and I appreciate the fact that you are bringing us here on a host of the key issues to look at these matters. I look forward to our witnesses.

[The prepared statement of Senator Wyden follows:]

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

Today the Committee will hear from Admiral Gehman, who by all accounts is leading a thorough and objective investigation of the *Columbia* tragedy of February 1. In my view, it is important that Congress evaluate the findings of the Admiral's investigation as thoroughly and objectively as he has conducted it.

*The Economist* recently reported that "NASA spends the lion's share of its $15 billion annual budget on manned spaceflight," and then asked the question "Should it?" I believe that now is the time to reexamine the nation's mission in space and perhaps reallocate our resources. In the joint House and Senate hearing on the Space Shuttle *Columbia* tragedy on February 12, I told NASA Administrator Sean O'Keefe that I personally believed more unmanned space flights would guarantee the most efficient use of resources. In my view, it is time to ask whether research projects currently within the space shuttle program can be conducted efficiently and effectively on an unmanned vehicle. In addition, now is the time to make sure that manned space flights are safer and more efficient as well. While we are here today to discuss the accident investigation, we must keep in mind the broader picture and think about establishing a new course for the future of our space program. We owe the men and women of the Space Shuttle *Columbia* that much.

The CHAIRMAN. Thank you, Senator Wyden.

Senator Allen?

**STATEMENT OF HON. GEORGE ALLEN,**
**U.S. SENATOR FROM VIRGINIA**

Senator ALLEN. Thank you, Mr. Chairman, for having this hearing.

And, Administrator O'Keefe and Admiral Gehman, thank you for appearing before this Committee. And, more importantly, I want to commend you for your tireless, your honest, and your open efforts in the last three-and-a-half months since this disaster occurred.

Briefly, I would like to make three points. First, Admiral Gehman and Administrator O'Keefe, I think you all have done an outstanding job in responding to the concerns of Congress and responding to our concerns insofar as the investigation Board and its independence from NASA. When one looks at this tragedy compared to that of the *Challenger*, the *Columbia* investigation, in my view, is certainly more expeditious and certainly more forthright; not to criticize the other, but I think you have made a substantial, significant, and noticeable improvement in that openness, forthrightness, and the speed in which you are sharing that information and getting on it. I think that those efforts are helping us, and you are to find the underlying and contributing causes of this tragedy.

Secondly, I want to echo and underscore previous comments about NASA's human space flight program. Virtually every aspect of NASA depends on the success of the Shuttle and the human space flight program. Generally, I look at space flight as a means to a greater end, which is research and discovery and exploration, and I know the brave crew of the *Columbia* engaged in a wide variety of scientific research; in fact, research that only could be done in space. I truly believe that if anything good can come out of this tragedy, it would be a reinvigorated focus on NASA and its primary mission of scientific research that actually benefits people here, life here on this planet. Some of the comments of the Chairman, in my view, to the extent you end up funding extraneous matters that are not the primary focus of NASA, it diminishes that capability.

Now, finally and thirdly, I have previously raised concerns about NASA in the area of one of its primary functions, which is aeronautics, and also, insofar as space is concerned, the advancements in technology; specifically, embracing some of the advancements in nanotechnology, that I know Senator Wyden shares my views on, as well as automation and robotics that could potentially minimize the risks associated with human space flight. I am interested in learning any specific areas where NASA is embracing some of these advancements in automation and robotics, which I believe are essential for us here in Congress, as well as NASA, to work together to get that right balance of humans, as well as the advancements in robotics and automation to function in these scientific research projects that are done in space.

And I thank you, Mr. Chairman, for having this hearing, and thank both gentlemen for your leadership.

The CHAIRMAN. Thank you.

Senator Breaux?

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

Senator BREAUX. Thank you, Mr. Chairman.

Very briefly, I think that it is good that we are having this hearing. Out of the tragedy of *Columbia*, hopefully, can come some good, and hopefully the good will be an assessment of where we are and where we need to be, what steps need to be taken to make sure that the launch vehicles for future flights are safe and dependable. And I think that hopefully we can start focusing in on what we need to do to meet the needs of the future after we determine the reasons for the accident itself.

One of the things that has given me great concern is that there is no replacement vehicle for the Space Shuttle. Not only is there not a replacement vehicle, there is not even anything on the drawing Board. And if somebody came to the Administrator tomorrow with the best designs for a new vehicle, it would take a substantial amount of time to put that vehicle into construction and, ultimately, into use. I mean, these are 15-, 20-year projects, at the very least. And right now I think the failure of all of us is that we have not made preparation for what is going to come after the Shuttle, and it's not a one-week proposition; it's a 15-, 20-year proposition. And right now there is nothing on the drawing Boards, and I think there is probably a lot of fault to go around for all of us as to why that is the situation.

But we thank our witnesses this morning.

[The prepared statement of Senator Breaux follows:]

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

The future of space flight will be composed of many things, including a vehicle we trust, a program that makes sense and has a clear and undeniable purpose, and an institution we think is designed to take on the challenges of the future.

NASA was originally designed to take on a single challenge, single-mindedly, and work until it was achieved. Since then, NASA has taken on many other challenges that compete for NASA priority and compete for funding in the national debate about space.

While we have seen steady progress in some areas of space—including the marvels of the Hubble and our recent visits to the planets Jupiter and Mars—we have seen many missteps in the human space program, particularly in attempts to generate a second generation of reusable launch and service technologies. Now, with the loss of *Columbia*, we are far behind in these efforts, with no clear agenda forward that we can see.

Today is a stage-setting hearing. We are anxious to hear the views of Admiral Gehman about the accident he's been examining, and to hear Mr. O'Keefe's response. And we are anxious to determine what happened and what it means, how fast we can recover, and, at the end of process that has yet to have begun, where we are going.

For too long we have had a national program in space, but not a national commitment to space flight. The accident that occurred last February is not the fault of any single individual—it is the fault of anyone who did not contribute their best to this program that a very few, our astronaut heroes, commit their lives to and others commit their careers to.

Mr. Chairman, I think the future looks different from the past, but I cannot today tell you how: A different vehicle; a different ambition; a different way of doing business. Today is our first attempt to visit these questions at a time I believe will be seen as a turning point in the future of space. Let us get on with the debate, because our space program has been waiting a very long time for this discussion.

The CHAIRMAN. Thank you, Senator Breaux.

I want to thank Administrator O'Keefe and Admiral Gehman for their outstanding work. We will have some tough questions, and I hope we can have some meaningful exchanges. But none of that, I believe, will diminish the respect and appreciation that we have for both of you and your service to this Nation. We thank you.

Administrator O'Keefe, begin with you, please.

**STATEMENT OF HON. SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

Mr. O'KEEFE. Well, thank you, Mr. Chairman and Members of the Committee.

Much has happened, I guess, since we last had an opportunity, February 12th, for this Committee and the Joint Committee with the House Science Committee, to discuss the specific aspects of the *Columbia* tragedy.

First and foremost, over the course of the six weeks after the tragedy, I have personally attended nine separate memorial services and every funeral, which—I am still stunned, I think, by the extraordinary effort that the Air Force, and the Navy, particularly, went to render full honors to all of the members of the crew of *Columbia*. It was an extraordinary effort, and I think it honored and respected their memory in an extraordinary way.

The recovery effort that occurred over the course of the last 100 days was equally impressive and one that I do not think anybody expected we would recover much more than about 10 percent of the orbiter. Instead, over the course of that time, better than 20,000 people in 200 different federal, state, and local agencies and departments from the State of Texas, State of Louisiana, the various communities, as well as the Federal Government, conducted the most impressive interagency, intergovernmental recovery effort that has ever been recorded. And, in the course of that time, there was no less than about 6,000 people in the East Texas/West Louisiana area that were engaged actively every single day in working through an area that is depicted on this particular chart, from a little southeast of Dallas, Texas, into Vernon Parish in Louisiana, that is the equivalent of—250 miles and about ten miles wide—this is the equivalent, in acreage, to the size of the State of Rhode Island. And the teams from NASA, the U.S. Forest Service, the Environmental Protection Agency, and countless state and local agencies and departments literally walked every single acre of that area and recovered now what is the better part of about 40 percent of the orbiter and what is equivalent to about 83,000 tons of the orbiter itself, which has now been shipped to the Kennedy Space Center.

Our activities in that area demonstrate, I think, some of the most remarkable efforts at interagency cooperation that is a model for how that cooperative effort can be conducted in pursuit of a common objective in ways that there were absolutely no—and every single trip I made to the area was stunned to see that there were absolutely no conflicts between and among agencies, between state and local officials. The Federal Emergency Management Agency conducted the primary coordination of that effort, but it was one that required little cooperative assistance or instigation on their part. It was extremely well-handled and one that we are ex-

tremely proud of and thankful to the Governor of the State of Louisiana and the Governor of the State of Texas for their extraordinary contributions, as well as cooperation, as we worked through this.

This particular land area, I think, is—and, I guess, in the category of remarkable developments, as well—is occupied by about 400,000 citizens in a stunningly—inasmuch as this was tragic and horrific for the loss of seven very important lives, it is amazing that there were no other collateral-damage efforts as a result of it. No one else was injured, all of the claims have been very, very minor in dealing with these issues. But an awful lot of debris was recovered, and the wreckage itself has been, again, now reassembled, in large measure, at the Kennedy Space Center, which is informing the investigation in ways that we are exceeding our expectations in many respects. I will certainly defer to Admiral Gehman on this commentary on that point.

As it pertains to the cooperation with the Board itself, there is no element of what they may desire, require, or need that we have denied. And, indeed, our effort has been to cooperate with the Board on each and every issue that is necessary in order to reach a common objective, which is to determine the truth, find the facts and the evidence to support exactly what happened and how we may go about the process of fixing it and return to flight safely as soon as we can.

In that regard, the return-to-flight efforts that we have engaged in is, rather than wait for the final report to be released, as Senator Breaux alluded, and Senator Wyden, as well, there are a series of recommendations that the Board has released as findings and recommendations thereafter that we are beginning to implement now rather than waiting for that activity to be in its totality. Our effort is to follow the better than nine separate public hearings that have been conducted, as well as the public commentary that has been offered by the Board, in order to inform the kind of approaches we need to take to return to flight expeditiously, but safely in doing so. So there is a range of different recommendations and findings that they have come up with that we are beginning now to implement, and we will continue throughout the course of their activity to engage in that activity as rapidly as we possibly can.

Finally, I do want to thank the Board members for their diligence, their literally six/seven-day-a-week activity that they have conducted for the past 100 days. They were appointed and assembled on the very first day of the accident, and have been unceasing in their efforts since then to find the truth and to find the evidence to support what happened on that day so we may make those corrections and move on to safe flight again.

In particular, I want to thank Admiral Gehman, who responded to my call hours after that horrific accident and pulled him out of retirement—blissful, I think, retirement—in which he certainly had lots of other things to do than return to public service in this situation. He has been relocated to Houston, Texas, for the entire three-month period since that time and has conducted what I think is a very thorough effort to date at this point.

I thank you, Mr. Chairman.

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

PREPARED STATEMENT OF HON. SEAN O'KEEFE, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Committee, I appreciate the opportunity to appear before the Committee with Admiral Gehman to discuss our ongoing efforts to honor the solemn pledge we have made to the families of the crew of *Columbia* and to the American people. That pledge is 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 motivated the *Columbia* astronauts and inspired millions throughout the world.

Much has happened since I appeared before this Committee and the House Committee on Science at a joint hearing on February 12, less than two weeks after the tragic accident.

Most importantly, a grateful Nation has laid to rest with full honors six American heroes: Rick Husband, William McCool, Mike Anderson, Dave Brown, Kalpana Chawla and Laurel Clark. The people of the state of Israel also paid their final respects to Israel's first astronaut, Ilan Ramon. We continue to be sensitive to, and supportive of, the needs of the astronauts' families and will be at their side as long as they desire our support.

We appreciate that the FY 2003 Omnibus Appropriations Act included $50 million in funding to help pay for the costs of the recovery operation and accident investigation by the *Columbia* Accident Investigation Board (CAIB). We have established new accounting codes in the NASA financial system, titled *Columbia* Recovery and Investigations, to capture these costs. We are monitoring very closely the costs associated with this effort and we will ensure that Congress is kept apprised of our continued progress.

I would like to thank the Committee for their expeditious enactment of the Columbia Orbiter Memorial Act which authorizes construction of a Memorial at Arlington National Cemetery in recognition of the STS–107 *Columbia* astronauts. In addition, NASA has established the NASA Family Assistant Fund which enables NASA employees to help provide for the families of the STS–107 crew and families of other NASA employees who have lost their lives while serving the Agency.

NASA is deeply grateful for the support we have received during recovery operations from the men and women from the Department of Homeland Security, including the Federal Emergency Management Agency, National Transportation Safety Board, Environmental Protection Agency, Federal Bureau of Investigation, Department of Defense, Department of Transportation, U.S. Forest Service, U.S. Park Service, Texas and Louisiana National Guard, State and local authorities, and private citizen volunteers who have helped us locate, document, and collect debris. In visiting with these folks, I can report to the Committee that the morale and commitment of the recovery team was an inspiration to me and to the entire NASA family. The outpouring of support from the local businesses, community leaders and the citizens of East Texas have especially humbled us. During the past three months there were approximately 5,700 personnel in Texas at any one time involved in the Shuttle material recovery. More than 20,000 people in all helped with this effort.

The recovery operations, which stretched from San Francisco, California to Lafayette, Louisiana, are essentially complete. Nearly 85,000 pounds of debris have been recovered, representing approximately 38 percent of *Columbia's* dry weight. Of the nearly 83,000 specific items recovered from the accident, more than 79,000 have been identified, with 762 of these coming from the left wing of the Orbiter. We are continuing to search some remote areas in western Texas, Utah and New Mexico.

As of May 5, the Lufkin Operations Center had completed searches in all 169 Texas counties that reported Shuttle material sightings. The Lufkin Center closed on May 10 and we have transitioned to a smaller scale Recovery Operations Center located at the Johnson Space Center in Houston. We are hoping that in the fall, when vegetation dies back, hunters and campers may find additional debris. In fact, directions for reporting any debris will be given to each hunter as he or she applies for licenses.

I am saddened to note that one of the helicopters searching for debris from the Space Shuttle *Columbia* crashed in the Angelina National Forest in east Texas on March 27. Buzz Mier, the pilot and Charles Krenek, a Texas Forest Service Ranger were killed in the crash, and three other crewmembers were injured. Our thoughts and prayers go out to the families of the helicopter crew members killed in the accident.

Using video of *Columbia's* re-entry provided by research institutions and helpful citizens, along with radar and telemetry data, we have identified several additional search areas in West Texas, Utah and New Mexico. To date, no material in these areas has been positively identified as coming from *Columbia*.

**NASA Cooperation With Columbia Accident Investigation Board**

The investigation of the CAIB is progressing. NASA recognizes the need for a credible and thoroughly independent inquiry and is fully cooperating with the Board.

The Contingency Action Plan and Standing Investigation Board were activated within an hour after the *Columbia* accident. This standing Board was the result of the lessons learned from the *Challenger* accident in 1986, which indicated the importance of having a panel of qualified investigators ready to initiate work immediately following an accident. Subsequent to the Board's formation, we received advice and counsel from Members of this Committee, as well as your colleagues in the House of Representatives and others, that the Board's charter should include revisions to guarantee its complete independence in the investigation and to ensure that the investigation be as thorough as possible. NASA has been responsive to these suggestions and has moved expeditiously to make appropriate changes to the charter and to add members to the Board to expand its composition.

More broadly, across our entire organization, NASA personnel are cooperating with the work of the CAIB. We continue to coordinate and categorize the collection of debris along the path of *Columbia's* re-entry and reconstruct the orbiter at the Kennedy Space Center. We are collecting and providing the Board with integrated image analysis and data. We are conducting fault tree analyses to look at all possible causes of the accident that the Board will independently validate.

In summary, the men and women of NASA fully understand and support the important work of the CAIB. We look forward to learning from and acting on the Board's recommendations.

**Status of International Space Station and Hubble Space Telescope**

While waiting for plans to be made for their return to Earth, the ISS Expedition 6 crew—Commander Ken Bowersox, Science Officer Donald Pettit, and Cosmonaut Flight Engineer Nikolai Budarin—continued to perform science and routine ISS maintenance on orbit. The Expedition 7 crew—Edward Lu and Yuri Malenchenko—arrived at the ISS aboard the Soyuz early Monday, April 29. The Expedition 6 crew returned to Earth on May 3.

In the absence of Shuttle support, NASA and the International Partners are addressing contingency requirements for the ISS for the near-and long-term. In order to keep the Expedition 7 and future crews safe, we must ensure that they have sufficient consumables, that the ISS can support the crew, and that the crew is able to return safely to Earth.

Working closely with our International Partners, we have confirmed that the ISS has sufficient propellant to maintain nominal operations through at least the end of this calendar year. With the docking of the Progress re-supply spacecraft on February 4 (ISS Flight 10P), the crew has sufficient supplies to remain on the ISS through August without additional re-supply. The next Progress flight is scheduled for June. As we move beyond June, however, potable water becomes the constraining commodity. We are currently working closely with our Russian partner, Rosaviakosmos, to explore how best to address this issue on future ISS re-supply missions.

All remaining U.S. manufactured International Space Station hardware for the Core Configuration has been delivered to the Kennedy Space Center and element ground processing is on schedule. The Node 2 module for the Space Station, built for NASA by the European Space Agency, will be delivered to the Kennedy Space Center by early this summer. Only one Space Shuttle mission to the Space Station in the critical path to U.S. Core Complete, STS–118, was scheduled to use *Columbia*. A revised U.S. Core Complete assembly schedule and subsequent deployment of international partner modules after installation of Node 2 will be confirmed when the Shuttle is ready to return to flight status.

With respect to the Hubble Space Telescope, all of our remaining Shuttle Orbiters are capable of supporting any necessary servicing missions. Currently, the Hubble Space Telescope is performing well, and this robust observatory is in no immediate need of servicing. Should a delay in the planned November 2004 servicing mission occur that impacts the Telescope's ability to perform its science mission, the Hubble can be placed in safe mode until a servicing mission can be arranged.

**Anticipating a Return to Flight**

We have begun prudent, initial planning efforts to prepare for "Return to Flight" in order to be ready to implement the findings of the CAIB. NASA's Return to Flight analysis will look across the entire Space Shuttle Program to evaluate possible improvements in safety and flight operations in addition to implementing all of the recommendations of the Board.

I have selected Dr. Michael A. Greenfield, the Associate Deputy Administrator for Technical Programs, to lead our Return to Flight activity along with William Readdy, our Associate Administrator for Space Flight. They will co-chair the newly formed Space Flight Leadership Council. The Council is composed of the Associate Administrator for Safety and Mission Assurance, the Deputy Associate Administrator for International Space Station and Space Shuttle, and the four Space Flight Center Directors. The Council will review and assess each course of action recommended by the Return to Flight Planning Team and provide direction to the Space Shuttle program for implementation. The Return to Flight Planning Team is already working to incorporate the CAIB's first two preliminary recommendations into the Return to Flight strategy.

In the interest of assuring that NASA fully addresses each of the CAIB's recommendations, I have asked Tom Stafford to lead a team that will provide an independent assessment of NASA's strategy for implementing the CAIB's recommendations. We are working to define the full membership of the team.

I would also like to thank Admiral Gehman and the rest of the Board members for the thorough and diligent manner in which they are conducting their investigation. We are grateful for their efforts. We will make our human space flight program better and safer because of their work.

As I stated earlier in my testimony, we still have a long road to travel until we can return the Shuttle to flight. The lessons of past accident investigations tell us that we have reached a critical juncture in the process of evidence gathering and analysis at which patience is absolutely required. I commend the Members of this Committee for their support of this vital investigation. We at NASA look forward to continuing to work with the Committee to ensure that we learn from this accident, move forward to develop and utilize the capabilities that can best and safely help us achieve our national objectives in Aeronautics and Space Research and Exploration.

Mr. Chairman, thank you for calling this important hearing. I look forward to responding to your questions.

The CHAIRMAN. Thank you.

Admiral Gehman?

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

Admiral GEHMAN. Good morning, Mr. Chairman, Senator Hollings, Members of the Committee. I appreciate the opportunity to appear before you this morning.

Rather than read my statement, I will just ask that it be entered into the minutes, and I will just——

The CHAIRMAN. Without objection.

Admiral GEHMAN. Thank you very much. And I will just make a couple of brief points, and we can get on to business.

First of all, I would like to introduce a couple of my fellow Board members, who are here today. Seated behind me is Mr. Steve Wallace, the Chief of the Aviation Safety Division of the FAA, and Dr. John Logsdon, from George Washington University, who is the Chair of the Space Policy Division.

The CHAIRMAN. Welcome.

Admiral GEHMAN. And also, the real strength behind my move to Houston, my wife, who's sitting behind, me, too.——

The CHAIRMAN. Welcome, Mrs. Gehman.

Admiral GEHMAN.—Members of the Committee——

The CHAIRMAN. Thank you for your service.

Admiral GEHMAN.—Members of the Committee, I am delighted to appear before you and answer all of your questions fully and completely on any matter that you would like to hear about. I would have to say, however, that this report is not written. And I will be delighted to give you my personal opinion, but this is a Board of 13 members, some of whom feel very strongly about some of these matters, and I do not want to overstate our progress or get ahead of my headlights here. Many of the things that you are interested in the Board has not decided upon.

So I will have to caveat my answers by, when I know that the Board is comfortable with a subject or when the Board has not even addressed the subject yet, and give you my personal opinion. So if you will excuse me for that caveat right at the beginning, that I am delighted to give you an interim report, but we have not written this report yet.

The intent of our Board is to provide you with an independent analysis and an independent review of not only this accident and what caused it, but also a deep, rich, complete, and intrusive inquiry into the entire manned space flight program. The goal of our Board is to hit the target. The target is determined by you, the Members of Congress. And in my dialogue with Members of Congress, which I have found very helpful, I have noticed that the target tends to move a little bit, which is perfectly all right. And it is that dialogue which allows me to adjust my aim, adjust my sights, so that we meet your requirements.

Several Members of Congress have indicated to me that when my work is finished, yours is just beginning, and, "Please don't hand me a half-baked loaf," and I understand that.

Our intent is to give you a complete, rich, deep review of this program, a review which has not been conducted before by any other Board. And in order to do that, we are using some old, well-proven, tested tools that get into the culture and the attitudes and the processes and the management and the climate that cannot be gotten into by any other way.

Mr. Chairman, you, as a naval aviator, are very familiar with the safety-review process that is used in several agencies, and we have found, over the years, that that is a process that allows you to get a look at an organization that you cannot get by any other process.

So you really have two investigations in one here. You have an accident investigation, what happened, that is being done in complete public, with full disclosure, public hearings, interim recommendations, lots of press conferences, plenty of oversight; and then we have a safety investigation, which is being conducted in accordance with procedures that have been set up by several agencies in the Executive Branch, which allows you to get the kind of look that you cannot get any other way. It is the opinion of the Board that that will allow us to write a report which will be of aid to Congress in a way that no other review of NASA has ever given you before, and it cannot be done any other way, in our opinion.

The Board is fully aware of the oversight responsibilities of Congress. We are fully aware of your requirements. And we are meeting right now, our staffs are meeting right now, to find a way to fully meet all of your requirements in some fashion or another, which I am advised, even though I am not an expert at this, that

these processes have been worked out between the Executive Branch and the legislative branch many times before, and there are processes to allow you complete access to anything you want to see. So until we agree on all of what those processes are, I do not want to get ahead of myself here. But I do not see this as a problem, meeting the oversight responsibilities of Congress in a way that is satisfactory to you.

Meanwhile, the Board wants to hold onto this tool, which is going to give you a better product, and a product that you will not have had the advantage of having before. Enough said on that.

This Board is completely independent. Contrary to some of the—I have got to watch my words here—headlines of the past, NASA does not pay our salaries; you pay our salaries. The Congress enacted a $50 million grant to conduct this investigation. NASA keeps the books for me, but I spend that money. So somehow suggesting that members of this Board are influenced by the way the records are kept, I find to be somewhat naive.

I also would like, on behalf of the Board, to recognize and acknowledge the work of the thousands and thousands and thousands of volunteers who have spent weeks and weeks walking through the State of Texas picking up debris. This serves two purposes, one of which is a public-safety purpose, because some of this debris is hazardous, and to get it up and out of the ground and out of the streets and schoolyards and public places is very important.

The second point that I would make is that it turns out that the analysis of this debris and the reconstruction of this debris has been very important to this Board's work. It turns out it was more important than we ever thought it would be. We have learned a lot of things from analyzing and learning from the debris. So it turns out that that work turned out to be more critical and more important than we thought it would be at the first, and we owe a great debt of gratitude to a whole lot of people who are never going to get their names in the paper and their pictures on the paper. So I would like to second that, too.

Let us see. And I think that with the exception of the points that I make in my prepared statement, I think that I best could serve this Committee if I stopped and responded to the questions.

Thank you for the opportunity, Mr. Chairman.

[The prepared statement of Admiral Gehman follows:]

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

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

It is a pleasure to appear today before the Commerce, Science and Transportation Committee. I thank you for inviting me and for the opportunity to provide an update on the progress of the investigation into the tragic loss of the Space Shuttle *Columbia* and her courageous crew of seven.

My intent today is to provide the Committee with the latest information on the progress and direction of the *Columbia* Accident Investigation Board and its three and a half months of investigation. I am prepared to explore any area in which you or the Committee are interested; however, in order to be concise I've limited my prepared remarks to these three areas:

- The Board itself
- The accident investigation
- Matters beyond the initiating event

**I. The Board Itself**

Within an hour after the accident, Administrator O'Keefe activated the accident contingency plan and the standing mishap Board that was called for by NASA procedure—a procedure adopted based upon lessons learned from the *Challenger* accident. The standing Board, excluding the Chairman, had seven members appointed by position, not name. These are positions such as the Commander of the Air Force Safety Center, the Commander of the Navy Safety Center, the Director of the Federal Aviation Administration's Office of Accident Investigation and the Division Manager of the Department of Transportation's Aviation Safety Division, among others. These experts are all Federal Government employees. They are arguably some of, if not the, most experienced and knowledgeable aircraft accident investigators in the world.

To augment this standing Board, we immediately started adding non-government, non-NASA people, starting with me. As the need for additional expertise and the amount of actual work grew, I added, in my capacity as Chairman of the Accident Investigation Board, a total of five more non-government, non-NASA Board members. This brings us to where we are now: Thirteen Board members, which just happens to be the same as the number of members of the Rogers Commission. Only one of these professionals has any significant connection with NASA.

I want to emphasize that our Board members are active investigators, not passive listeners. We are in session seven days a week and have been since the first week. We have developed a staff that is almost exclusively non-NASA. We are following many precedents set by the Rogers Commission, including using the Department of Justice to archive records and using frequent public hearings to allow our progress to be monitored by all of our constituents. We are taking all possible advantage of other organizations with applicable expertise. These include, among others, the National Transportation Safety Board, the Department of Defense, the National Oceanic and Atmospheric Administration, the National Safety Council and the Federal Emergency Management Agency, just to name a few.

Mr. Chairman, as a Naval Aviator, I am sure you will appreciate the significance of the Board's extensive use of the special tools available to us under the rubric of a safety investigation. We are gaining insights into areas we would not be privy to under other investigatory models. The benefit of this process will flow directly to you and your Committee in the form of a deeper and much more complete view into Shuttle Program processes, management, safety programs and quality assurance.

**II. The Accident Investigation**

The Board has made excellent progress in gaining a precise picture of the environment and forces acting on the *Columbia* in her last ten minutes of flight. Through detailed and exhaustive scientific and engineering analysis and through just plain hard work, we have determined the facts related to the loss of the Shuttle and her crew. While I cannot lay out for you with absolute certainty the entire chain of events that led to this catastrophe, I can tell you that the pieces of this puzzle, particularly regarding the mechanics of the accidents, are fitting together with increasing precision and consistency.

As a means for cross-checking the consistency of our evidence and findings, we are simultaneously building six separate "pictures" or scenarios of the accidence sequence. These "pictures" may be labeled:

- The aerodynamic scenario
- The thermodynamic scenario
- The detailed system timeline from telemetry and recovered on-board recorder
- The photographic and videographic scenario
- The story the debris reconstruction and analysis tell us, and
- The story the records of maintenance and modification work tell us . . . .

We have developed each picture quite accurately; we then overlay the scenarios one on the other to find the best fit. All six scenarios point toward the same conclusion: that the *Columbia* entered the Earth's atmosphere with a pre-existing deformation in the leading edge of the left wing. That deformation allowed super-heated air, well above 3,000 °F, to get into the wing's internal structure over a period of 10 minutes. After a few minutes, the heat-damaged wing began encountering significant aerodynamic forces with which it could not cope.

When traveling at over 12,500 miles per hour, it doesn't take a lot of damage to create significant heat and significant aerodynamic forces. Because the Shuttle maintained a nominal flight path and altitude until the very end, we believe the accident itself was sudden and catastrophic. Mr. Chairman, while the Board ultimately expects to speak with a high degree of confidence regarding the entire acci-

dent scenario, at present we are not entirely confident that we know for certain what physical event initiated the failure chain of events. We are all aware that the left wing was struck by External Tank insulating foam 81 seconds after launch, but to date, we are still looking for hard evidence that this foam strike caused any damage to the left wing. We are conducting tests now to help fill in this critical link in the chain of events.

**III. Matters Beyond the Initiating Event**

Defining the point of the origin and timing of the failure sequence is extraordinarily important, but this by itself does not satisfy our requirement to find both the contributing and underlying causes of this accident. We also must determine why and how this failure process got started in the first place. We are looking in parallel at all related processes that pertain to the Shuttle system as a whole. These processes include, but are not limited to: safety, risk management policies and practices, quality assurance, maintenance practices, consistency in control of waivers and anomalies, turnaround processes, preparations to launch, work force issues, budgets, and the group dynamics of all Boards and committees that NASA has set up to ensure inter-disciplinary coordination.

Mr. Chairman, the Board intends to draft a final report that places this accident in context. By "in context" I mean we will attempt to build a complete picture of how this accident 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, work force trends, management issues and several other factors—each of which may contribute to a safer program to a greater or lesser degree.

We on the Board are fully aware that when our work is finished, your work will be just beginning. We have set a high intellectual bar for the Board to clear. That bar is this: our report will be of sufficient depth and breadth that it will serve as the basis for a complete public policy debate on the future of the Space Shuttle Program. We believe we can both find the cause of this accident and relate it to these other issues.

As we find items relevant to the return to flight decision, we have and will continue to release those results in the form of interim findings and recommendations, similar to the way the National Transportation Safety Board does in its aircraft accident investigations. These will both keep the Congress, the Administration, and the public informed of our progress and allow for interim work at NASA to proceed as quickly as possible.

Mr. Chairman, speaking for the 13 dedicated experts on the Board and the thousands of people working to solve this mystery, I can assure you, the astronauts' families, and the American people that we will spare no effort to get to the bottom of this. I estimate that we are better than half done. We have all the assets and expertise we need, or we know where and how to get it.

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

The CHAIRMAN. Thank you. Thank you both.

There are several issues that I would like to address, and we may have to have subsequent rounds. But the first issue I want to discuss with you concerns whether satellite photos could have been taken of the *Columbia*. And if so, would it have mattered in helping prevent this tragedy?

Now, from my standpoint, here is what happened. I was notified shortly after the tragedy, in a highly classified fashion, that the National Imaging and Mapping Agency had offered to take satellite photos of the *Columbia* in order to ascertain whether, if any or the extent of, the damage was a result of the foam striking the capsule on launch.

Now, I was originally briefed that the offer was rebuffed by NASA and that the offer had been made on several occasions. I consulted Senator Hollings, and we discussed it and sent a letter to Administrator O'Keefe asking for information concerning this situation.

It is still not clear to me what happened, who is responsible, and whether a picture or imaging could have been rendered, if it had been given sufficient priority, which may have provided information that would have at least alerted NASA and the people onboard *Columbia* that there was a significant problem.

So Admiral Gehman, you may not have reached any conclusion on that yet. But I would like to hear information from both you and Mr. O'Keefe, beginning with you, Administrator O'Keefe.

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

I am certainly going to be a bit circumspect in the response, given how chary the intelligence community is about discussing the full extent of the quality of the imagery that is made available or the products that are available from the intelligence community. But as we have discussed——

The CHAIRMAN. Could I just remind you, Senator Hollings and I communicated to you in a classified fashion. It was not until information was in the media that we felt free to discuss this issue.

Mr. O'KEEFE. Oh, yes, sir. No, no.

The CHAIRMAN. Go ahead.

Mr. O'KEEFE. And in response to your joint letter, recall that, immediately, we responded on an unclassified basis, as well as classified information, to provide that information, as well. And then we have discussed this several times in closed session.

Nonetheless, the procedure that was followed during the course of this operation, and prior, was the National Imagery and Mapping Agency had an agreement with NASA that, upon our request, they would provide products from the assets that they operate. That procedure required a level of import that had to be attached to it, whether it was routine, an emergency, urgent, you know, et cetera, that kind of—"How serious is your problem," essentially was the nature of the MOU.

In this particular context, there was certainly the dialogue that goes on every day between NASA and NIMA on matters of availability of assets in which there were offers rendered in which they asked that there be some attachment of urgency to it. Based on all of the Mission Management Team's assessment in that 16-day mission, their judgement was there was no safety-of-flight consideration. So we have certainly asked the agency to make available those products to the extent that was available and easy to do on a normal, routine basis.

Given the other priorities, which we are totally unaware of that NIMA has and has to respond to, their judgment about exactly how that is made available is their call. If we had said, "We have an urgent matter. We need you to take, use, or employ your assets for the purposes of releasing those products," they would have done so. We had no basis upon which to determine an urgency. That was a judgment call. We now realize that, given the circumstances, that may have been of greater utility. But at the time, in order to meet that criteria, we would had to have put a matter of some urgency attached to it.

As a consequence of this, and based on the findings and recommendations of the Columbia Accident Investigation Board, which was among the first two they have released, I have re-enjoined with General Clapper at NIMA and have asked him specifi-

cally to, "Let's disregard the MOU, let's rewrite it," and to simply make available imagery on every future operational mission as it comes available, period, without any qualification of its urgency or emergency requirements or anything else.

The quality of that imagery, of course, always depends upon a range of factors, and, as a consequence, there is no comparability between each and every available product, as it were. So, as a consequence, we will get wide-ranging degrees of quality of what may be useful in the future. But, nonetheless, we will get it, and there will be no ambiguity about that procedure. That MOU is being, the memorandum of understanding the two agencies, is in the process of being redrafted with that specific understanding between the two agencies unambiguous.

The CHAIRMAN. You have no idea as to whether that imagery would have revealed there was a problem.

Mr. O'KEEFE. Again, without describing what the extent of their quality is, let me simply say that the Tom Clancy novels would have us believe that the quality is extraordinary. They may not be as close to that reality as the novelists would have us believe. And, on that basis, it depends on a whole range of variables, and it is purely speculation on whether or not any of the products would have been of sufficient information to have given us any understanding. Indeed, I think Admiral Gehman's Board investigation process, while it has not yet determined what was the cause, the initial factor that caused this, it may well have been something that might not have been even determining based on any use of any product from any intelligence source.

The CHAIRMAN. I appreciate the indulgence of my colleagues. My time has expired, but I would like to hear from Admiral Gehman on this rather important issue.

Admiral GEHMAN. Thank you, Mr. Chairman.

You happened to hit on a good first question, because, as you may know, the Board has issued a recommendation on this subject, and, therefore, this is something the Board has agreed upon.

My evaluation when we write this section probably will be a little more critical than the Administrator's description. There are a number of issues here. We will attempt to pin this issue down in our report. But there were a number of bureaucratic and administrative missed signals here. There is no one person responsible; there are a whole lot of people responsible. The system did not work in this particular case. And I would not blame that on any one person.

We have listened to a lot of people, and we have gotten quite a bit of testimony on who said what to whom, and we have tracked the issue, we diagrammed it out, and we are a little disappointed at how the process worked. That is why we issued this recommendation. We were a little disappointed in what some of the senior people knew and understood about how you get these images and what the images can do for you. They did not understand. Some people in decision-making processes did not fully understand what they were talking about here. Some cases, people made decisions based on an erroneous understanding of what was happening. There were missed signals going up, and there were missed signals going down, too. And we are not quite so happy with the process.

We thought that there were some administrative and bureaucratic missed opportunities here. So we will be a little more critical of the process in our report.

Now, whether or not it would have made any difference, we will not be able to speak to that. Since we do not know the mechanical, physical initiating event, the—we do believe that the orbiter entered the Earth's atmosphere with a pre-existing flaw. But that flaw could be as small as two inches by two inches, or it could be larger. So whether or not any photography could have detected that is pretty argumentative.

But when we speak to the old-timers, some of the original flight engineers and flight directors and astronauts, they give us a slightly different view. They all say, "None of that makes any difference. This is a test vehicle. Of course you want pictures just so you know, and all the rest of this stuff is bureaucratic fumbling and bumbling."

So I can answer part of your question. The Board has investigated this. As illustrated by our interim recommendation, we have satisfied ourselves that this process did not work, that it was no one person's failure, but we cannot determine, to any satisfaction, that it would have made any difference.

I hope that answers your question, sir.

The CHAIRMAN. Senator Hollings?

Senator HOLLINGS. Thank you, Mr. Chairman.

Admiral Gehman, right from the get-go, what about the Chairman's observation that we need to have every statement, every bit of information that you folks on the commission of inquiry have made? Can we have all of those, or have confidentiality agreements been made to give cover for some of those statements that, in other words, cannot be made public or cannot be given to the Committee? What is your answer to the Chairman's request that we have all the information you have?

Admiral GEHMAN. Thank you, Senator.

As I indicated in my opening remarks, it is our belief that the Congress of the United States will get a better report from us——

Senator HOLLINGS. Well, I know we are going to get a better report. Let me ask, Have you given confidentiality agreements to anybody in this investigation whereby their statements will not be available to this Committee?

Admiral GEHMAN. We have, Senator, but——

Senator HOLLINGS. Well, there you go.

Admiral GEHMAN.—but that does not mean that their statements will not be available to this Committee. We have conducted witness interviews, in accordance with the safety procedures used by several branches of the executive branch, and there are processes by which this Committee can have access to those. And, as I indicated in my opening statement, those processes are now being negotiated by our staffs.

Senator HOLLINGS. Well, I am not clear yet. One minute you say you have given confidentiality agreements, and then you have got to argue with lawyers and so forth as to whether we get them. But anyway, that is by the pale.

The real important question is, could anything have been done to save those astronauts? Now, we know from Appollo 13 about the

ingenuity of NASA engineers. And you have got an ingenious group, Admiral, you and I have discussed it, and they know how to work and go and implement.

I disagree with the distinguished Administrator's observation that there was no urgency. The truth is, within 81 seconds, we knew that insulation had caused damage. The truth is that two days thereafter, the engineers were calling up and asking for an investigation and pictures. Boeing, I guess it was, made the investigation on potential foam damage, but they did not report until day 12. Now, that there would go along with the Administrator's "no urgency," but you had urgency on the other side. Namely, the Mapping Agency was calling up and saying, "We can get pictures. We can get pictures." You had the engineers calling for imagery. You call it "bureaucratic" and "missed signals." But, really, it was not until, like I said, day 12 that he found out, "Wait a minute, we should have done something."

Could anything have been done? I have talked to an astronaut or two, and they think that, yeah, you could have gotten another Shuttle up; otherwise, you could have turned that around for reentry so the cool side would be to where the damage had been inflicted. There are all kind of maneuvers that could have been made. But it just looks to me like somebody that saw that in charge just all of a sudden just crossed their fingers and said, "Well, it has worked before, let us hope it works again," and just, "Cool it, cool it. No, no, we do not want any pictures." In other words, they were refusing to get the pictures, not on account of urgency. The urgency was there.

What is your comment, Admiral?

Admiral GEHMAN. Senator, we, as a Board, early in this investigation, considered the question about, What, if anything, could have been done, or how close did the astronauts come to surviving this? And in the early part of this investigation, the Board decided that there were still too many emotions and too many egos and too many feet stuck in concrete to address that. Now, three months later in this investigation, we know more, some of the emotions are off the sleeves now a little bit, and we have just directed and just begun a formal inquiry into what could have been done. That inquiry is about ten days old. We think that the emotions are out of it. Some of the reluctance to discuss these things have—we have got a little separation of time now, so people can be cooler about this.

That investigation is going on right now jointly with our Board and a bunch of real smart people from NASA. And it is headed in a direction—it is too early to say—we have not found any magic fix. Let me put it that way. But I will say that it is inconceivable that we would come up with the answer that we could do nothing. I mean, of course, we would do something. And we have determined that, for example, that—the estimate of how long the orbiter could just hang up there, for example, the harder we dig into that, the longer that day gets. It turns out that they could have stayed in orbit a couple more days, more than a couple more days. And it turns out that the more we dig into this, the longer that number gets, and it gives you more opportunities to do things. And even if

we came up with a fix that only had a 10 percent chance of succeeding——

Senator HOLLINGS. We would have tried.

Admiral GEHMAN.—of course, we would have done something. Absolutely. So, thus far, this review, which I have looked at myself, I have found it to be pretty aggressive and pretty well thought out, has not found any magic formula, but has found several steps that could have been done to mitigate this. We may find more. But this is tough work for people who are closely associated with the program, and they are doing a good job of it. So maybe I will be able to get back to you later on.

But doing nothing is obviously not the right answer.

Senator HOLLINGS. Bless you.

How about Mr. O'Keefe?

Mr. O'KEEFE. Thank you, Senator.

I do not disagree with your assessment, Senator. It was a judgment call. It was clearly the wrong judgment. And as a consequence—I mean, what we know now, hindsight being the circumstance, there are a variety of signals that could have gone—or told us what we should have been observing and what we could have corrected. Nonetheless, the judgment by the Mission Management Team at the time was—they looked at the 16-day mission, they said, "Every one of the things we have observed"—all the spirited debate that you refer to; you are exactly right, lots of dialogue back and forth—in the end, they made a determination and said, "Do we think this is a more urgent circumstance than we have ever experienced before?" And the answer, rightly or wrongly, was they felt, in their judgment, this was not outside the normal. That certainly proved to be an erroneous judgment.

So, you know, looking back on this, there is no question. The clarity is there. At the time they went through it, the Mission Management Team certainly looked at that. I concur entirely with Admiral Gehman's assessment. But had there been a different determination, we would have spared nothing to find a way to return the orbiter and the crew safely to this planet. No question.

Senator HOLLINGS. But just one little observation. Of course, it does look like the judgment was made that it was urgent and it was perhaps a fatal injury to the Shuttle itself, and they determined to make sure that that was not proved by not taking pictures and those kind of things. Those are the things that worry us on the Committee.

Mr. O'KEEFE. Yes, sir.

Senator HOLLINGS. It looks like they knew it, and there was the urgency, and they knew about the urgency and everything else, but they tried to sort of cover up the urgency.

Mr. O'KEEFE. Well, if I could—yes, Senator. I entirely concur in Admiral Gehman's assessment of this. When you look at the memorandum of agreement between NASA and NIMA, there is nothing that really jumps out at you and says, "Geez, this looks like it is going to be a really bureaucratic procedure." In practice, it proved to be absolutely impossible to implement correctly. It was the wrong way to go about doing it. We have corrected that. There is no ambiguity about this point.

General Clapper and I have had some very specific, direct words on how to arrange this, and there is going to be no ambiguity on this point in the future. But there was nothing that would scream off that page of the memorandum of understanding that says, "What we have here is an impractical or impossible situation." In practice, I agree entirely with the way Admiral Gehman described it. It is something that you have got folks who do not know or were not aware of the quality of what could be available, and then a procedure that ultimately turned on the determination of NASA about what other priorities the intelligence community may require, singularly unqualified to make that judgment call. And so, as a consequence, it ground itself down to the null set, and that is what we have fixed. There is no ambiguity about this procedure any longer.

It is infuriating to see how that process played out, and I share your absolute frustration with the fact that that should not have occurred that way.

The CHAIRMAN. And it is equally infuriating that no one is responsible. Those decisions were not made by machines. Someone is responsible.

Mr. O'KEEFE. Yes, sir.

The CHAIRMAN. Senator Allen?

Senator ALLEN. Thank you, Mr. Chairman.

Let me switch from this line of questioning to the current operations. The Space Shuttle, while it is an old craft, it is still the most capable, it is reusable, it can carry loads, as well as, obviously, crew members, up to the Space Station. It is clearly a national asset that is currently grounded. My question is regarding the future of the Shuttle and the International Space Station. Specifically, what is our strategy that will be guiding the operation of the Space Station while the Space Shuttle is grounded?

Mr. O'KEEFE. Yes, sir, thank you.

Our partnership with the International Space Station partners of 16 Nations has demonstrated the depth of that partnership by responding and stepping up when we need that capability most; in particular, our Russian partners, and the Rosaviakosmos, the Russian Space Agency, have responded in a remarkable way, not only by accelerating the logistics flights that are necessary to resupply the International Space Station, but also to honor their commitments previously made to launch the Soyuz spacecraft, which will now be used for crew-rotation purposes.

I was in Russia weekend before last to, after several tense hours, welcome home the Expedition 6 crew, Ken Bowersox, Don Pettit, and Nikolai Budarin. And, just days before, Ed Lu and Yuri Malenchenko were launched on the Soyuz to man the Space Station as it is today on Expedition 7. So that rotational pattern will continue, and we will then maintain a capability there that, again, our International Space Station partnership has stepped up to the task of maintaining that capability independent of the Shuttle's operation.

The catch is we cannot continue to build the International Space Station, complete it, until we return to flight safely. And so the imperative for moving ahead, finding the problem, fixing it, and responding by returning to safe flight is the imperative of building

the International Space Station and conducting the activities that we had planned and worked through for so long.

Senator ALLEN. Well, implicitly, if we are doing simple math, we are sending two crew members now, rather than three, which then gets to the question of its capabilities and can two do as many as three. And then, following that is what is the strategy of NASA insofar as the balance between the use of manned space flight versus robotic satellites?

Mr. O'KEEFE. Yes, sir. Well, the maintenance of Expedition 7, as well as each crew hereafter that will be launched on Soyuz or recovered by the return of the attached Soyuz flight that is aboard now, is what is required to maintain continued safe operations of the International Space Station. It is a, you know, lights-on, fluids-running, you know, kind of maintenance capability, and some science. There is not a complete diminution of that. They are not just there as an engineering or maintenance crew, but they are—it does guarantee safety-of-flight operations and keeping it at the appropriate altitude in order to maintain safe operations.

So the diminution of one is more a function of how many folks can you support with logistics flight, the progress flights that are sent now—five a year is what we are planning—in order to maintain the logistics, the consumables—food, water, you know, repair spare parts, et cetera—and that is adequate in order to support two, not three. We could have maintained a longer or more extended presence of three crew members through early fall, but that would have drawn down the consumables faster, so we elected to make the change to two crew members earlier.

In terms of what is the future of human space flight and the imperative thereof, certainly this tragedy reminds us of the extraordinary risk that is taken when humans are engaged in space exploration. And in doing so, it means we have to absolutely convince ourselves of the imperative of why humans need to be involved in certain mission activities.

As it pertains to the operations aboard the International Space Station, I think in the opening comments from so many Members here of the Committee, particularly your statement that this be a science-driven research enterprise, indeed, that is its primary purpose. A lot of that can be done robotically. A lot of it can be done remotely. Some of it cannot. It requires human interaction and activity in order to divine the kind of science and research activities and experimentation that is necessary. The Hubble Space Telescope, classic example, again, of why human space flight is a very important element of the overall equation. Because when we launched the capability ten years ago, it was determined to be out of focus and was widely deemed to be a $1 billion piece of space junk. It has come back from the ashes as a consequence of that because of human interaction. Were it not for the capacity on the part of humans to make adjustments to that piece of machinery that could not be done remotely, it would have remained a billion-dollar piece of space trash. Today, it is rewriting the astronomy books, based on what we are learning from it, because of human interaction.

So we have got to be very selective, very careful, on how we engage in human space flight and expose the risk only when you see

the imperative is there for human interaction required. But, beyond that, I do not see a circumstance under which we would eliminate it entirely.

Senator ALLEN. But you do see an increased value in it——

Mr. O'KEEFE. Yes, sir.

Senator ALLEN.—as advancements go forward.

Mr. O'KEEFE. Absolutely. No question at all.

Senator ALLEN. My time is concluded. Thank you both.

Mr. O'KEEFE. Thank you, Senator.

The CHAIRMAN. Thank you.

Senator Wyden?

Senator WYDEN. Thank you, Mr. Chairman. Gentlemen, thank you.

And beginning with you, if I might, Mr. O'Keefe, and explore something with you that really goes back to the days when I chaired the Subcommittee on Science, Technology, and Space, now chaired very well by our colleague, Senator Brownback. And my sense, Mr. Administrator, is that there is really an urgent need for a thorough overhaul of the way people within NASA communicate with each other. If you look, for example, at the kinds of things that we are talking about here, and Senator Hollings and Chairman McCain have gotten into it, what we see is it just does not seem that the people on the front lines, the engineers, seem to feel that they are getting through to people up at the top. And you hear that again and again and again.

Now, I recognize that we are still in the preliminary kinds of stages in this area, but I would be interested in your sense, at this point, (a) whether you think that there really is a need for significant change at NASA with respect to how people communicate with each other, and (b) what you think some of the elements of—if you feel that way, what some of the significant elements of those changes ought to be.

Mr. O'KEEFE. Yes, sir. Well, thank you, Senator.

I do not disagree that we have got to constantly work to open the communications to garner and divine everyone's best judgment, advice, and opinion on the engineering and technical challenges we experience on a regular basis. There are two things that apply on this one that I have come to—looking at the record and all the E-mail traffic and all the reviews of what has occurred here.

The first one is that in this age of modern information technology, what we have created, again, as a consequence of it, is a very egalitarian process. When you look at the wiring diagrams of who was talking to who, who was E-mailing who, it was independent of where they fit on the overall hierarchical chain. There is nothing monolithic about how that approach was taken. Indeed, you have junior engineers communicating with very senior people in the organization on what they thought, and responding on that basis. So the Mission Management Team that conducted the in-flight-operations coordination effort encouraged and received an awful lot of commentary, from not just the folks within the space flight community, but outside of it, and solicited commentary from others. So that part is the good news.

The problem is it is much like anything else, where you are encouraging volume. It becomes a cacophony. You cannot quite put it in context, and, therefore, judgment calls get made.

And that is the second part that really is a pattern here that it concerns me a bit. We engage in an unbelievably rigid process leading up to launch. The flight-readiness reviews and so forth, everything prior to that is a very methodical effort that is a very hard lesson learned from *Challenger* in which everyone is encouraged to pipe up. There are all kinds of interaction. And then as soon as the operation begins, it becomes a group of folks in the Mission Management Team.

You know, this derives from, I think, a very tried-and-true kind of military operational procedure in which you want to hear lots of commentary; but, in the end, somebody has got to have the operational control of how this works and make decisions about it. There is a little less of a rigidity to that process, for good reason, in order to maintain flexibility and to be adaptive to circumstances as they present themselves.

But, nonetheless, this clearly—this indicates that yes, indeed, the premise of your question is right on. We need to really examine this carefully, not because there is not enough interaction, but its quality is confused. It is in volume, but not in any organized manner.

And in terms of how the operational management of a mission is conducted, it does not lend itself as well, from what I can divine, towards any prioritization of those observations.

So yes, indeed, sir, I am committed to that, looking at how we overhaul that function, and encouraging what is good about it and figuring out how to put some organization to it to make it meaningful.

Senator WYDEN. The other area I wanted to ask about, we have talked, obviously, about one of the recommendations, the preliminary recommendations, of the Columbia Accident Investigation Board with respect to the imaging issue, and I am pleased to see that you would have handled that issue differently. But what about the other recommendation calling for a comprehensive inspection plan to look at the structural integrity of the reinforced carbon-carbon system components?

Mr. O'KEEFE. Sure.

Senator WYDEN. Now, this, again, is a preliminary recommendation from the Accident Investigation Board, but certainly people have asked me, having been involved in these issues, why something like this was not done before the tragedy, and I am sure there are some technical questions in this area, but I would like to get your response for the record on that.

Mr. O'KEEFE. Yes, sir. Thank you, Senator.

Indeed, this is an area that the finding and the recommendation of the Board—you know, I will defer to Admiral Gehman in terms of the approaches they looked at to come to this conclusion; but, nonetheless, their finding and recommendation was right on the mark. These are the kinds of things that we need to develop.

The catch is, I am advised by our technical community, the engineering folks, that there is no specific nondestructive testing method that is available to do and accomplish what is necessary while

the leading edge is in place. And so, as a consequence, we work with our friends and colleagues at the Langley Research Center to develop such a technique, because there has been a lot of work on it, and a lot of folks have been talking about it trying to figure out how to do this, but there is no known technique where you can just simply say, "Let's go get that approach," and go do it. Instead, what it requires, you take the leading edge off and then examine it through a variety of different techniques rather than in place. And in doing so, the engineers are of the view that that, in turn, creates, unintentionally, the prospect that you may further damage or compromise the seals at each of the points of the leading edge itself. So what we have got to find is a nondestructive testing method in place in order to do this.

Now, having said that, during the course of every OMM process, which is the major maintenance process where you tear down the orbiter essentially every eight to ten flights, typically they will be removed and inspected through that process, or replaced, if need be. On *Columbia*, I believe, and I will defer to Admiral Gehman on the specifics of this, but some number of those leading-edge panels were replaced, but not all of them. Some of them were original material. And so the actual inspection of them may have been, and certainly was, inadequate during the course of that. But we are trying to develop a technique that would do just that.

Senator WYDEN. Mr. Chairman, if we could just get the Admiral's response on it, because I think the point Mr. O'Keefe was making is that to have really done the job as comprehensively as the Administrator would have liked, you needed to develop some new technology, and there were, I think I caught in the Administrator's comments, some flaws, even in terms of the inspection process that was used.

If that is the case, Admiral, could you tell us your thoughts with respect to the flaws in the inspection process? Because I have not heard that on the record.

Admiral GEHMAN. Yes, sir. Thank you, sir.

Once again, I will differ slightly in my analysis from the Administrator's analysis. Of the 44 panels on the two wings of the *Columbia*, 44 RCC panels, only three had been replaced. The other 41 are original equipment. They are 25 years old. The question is, Does anyone know whether or not those carbon-laminate pieces—which are not fiberglass, but think of fiberglass—which are subjected to weather and lots of other things, does anyone know the condition of those panels? And the Board was not satisfied that, like any other aircraft which is approaching its 20th or 25th year, an extensive amount of aircraft-aging analysis is done. The Board was not satisfied that a similar engineering kind of pattern was being followed by NASA.

And, indeed, every once in a while some of these panels are returned to the manufacturer—for example, if there is a visual flaw—and the manufacturer does these introspective, nondestructive kinds of testing. And guess what? On occasion, we find flaws, serious flaws, which are not visible to the naked eye. That led us to believe that we have a condition here—or we have an unknown condition. The Board is not saying there is anything wrong

with those RCC panels; the Board is saying that NASA does not know the condition of 25-year-old panels and that this is a big flaw.

And we, of course, wanted to make sure we did not say anything that was factually incorrect or anything like that, so we consulted experts inside/outside NASA. And, oh, by the way, when we consulted experts at NASA, we got the same pushback that the Administrator got, "Oh, by the way, the systems are not perfect. Yeah, we'll have to take them off in order to do this." But we found that to be not relevant to our discussion. You cannot fly an orbiter with 25-year-old pieces of equipment that you do not know the condition of them.

Senator WYDEN. Mr. Chairman, thank you.

The CHAIRMAN. Senator Snowe?

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

Senator SNOWE. Thank you, Mr. Chairman.

How many people would have been involved in the decision-making, once it was recognized after the Shuttle launch that damage had been done?

Mr. O'KEEFE. I will have to get you a head count for the record, but the Mission Management Team is composed of folks from the Johnson Space Center, the Marshall Space Flight Center, Kennedy Space Center; and primarily at Johnson, because mission control is operated there out of Houston. It is a fairly large number, but let me get you a precise one for the record here.

[The information referred to follows:]

The Mission Management Team (MMT) is responsible for each Space Shuttle mission, from launch to landing. The team is composed of the following members:

Manager, Launch Integration, (Chair, Launch MMT)*
Manager, Space Shuttle Program Integration, (Chair, Flight MMT)*
Manager, Space Shuttle SR&QA*
Manager, Space Shuttle Systems Integration*
Manager, Space Shuttle Vehicle Engineering*
Manager, EVA Project*
Director, Flight Crew Operations*
Director, Mission Operations*
Director, Space and Life Sciences*
Manager, MSFC Shuttle Projects*
Manager, RSRM Project
Manager, SSME Project
Manager, ET Project
Manager, SRB Project
Director of Shuttle Processing, KSC*
Manager, ISS Program (as required)*
Director of IS S/Payloads Processing, KSC
Commander, DDMS *
Flight Manager*
Program Manager, Hamilton Sundstrand*
Lockheed Martin Michoud Space Systems
Thiokol Corporation
Boeing-Rocketdyne
Boeing Company Payload Ground Operations Contact
SSP, Deputy Program Manager, SFOC*

The titles with asterisks represent those members who are required to be present during each mission.

Mr. O'KEEFE. But, in terms of active members of that team, there may be that many or more folks who are actually being

tasked or required to participate or whatever else. But in terms of decision-makers, you have got a very specified number of folks there.

Senator SNOWE. And how far up the chain of command does a safety-related question go on the day of the mission?

Mr. O'KEEFE. The mission management team is run primarily by the Shuttle program, which reports primarily to the Office of Space Flight in Washington, as well as to the center director at Houston. A safety issue would escalate all the way through that process quickly if the mission management team were of a mind that we had a safety-of-flight consideration.

Senator SNOWE. They did not, obviously, identify this as a serious safety-related issue.

Mr. O'KEEFE. They did not determine that, based on all the evidence, that there was a safety-of-flight consideration during the 16-day mission. That was a judgment call made by the mission management team, indeed.

Senator SNOWE. Yes, it just seems to me that there is no question that the whole decision-making process and communication and the bureaucratic structure that goes up through the chain of command has to be altered significantly.

Admiral Gehman, you had mentioned that no one is responsible. Well, that is the problem. When you have a committee of 100 or less, if everybody is responsible, no one is responsible. It is true. It has to change, I think, before any next launch, among other things, because we have to get to the root causes. It just appears to me that it was a very complicated decision-making environment when it came to making those kind of decisions, and red flags were not readily identified.

You could not access previous records or abnormalities that were associated with the *Columbia* Shuttle, and that is also of concern. You cannot have an antiquated system. If there were problems that had been identified with the *Columbia* Shuttle on previous flights, there was no way to access that previous experience readily or quickly in ascertaining whether or not this was a serious problem.

So if there was a growing list of abnormalities, there were no red flags being raised, because you could not access the lists; and you have a very cumbersome bureaucratic environment that does not raise a red flag with respect to this.

It is disconcerting, because—and I do not know if this is true; I read this in one of the newspaper accounts, talking about a memo that named over 30 high-risk concerns regarding tanks and foam and identified the idea of foam shedding from the tank and causing damage to the thermal-protection system of the tiles and panels. But over time, the space agency had come to classify the problem as a maintenance issue and not a serious threat to the safety of the craft or its crew.

But even though it might have been considered a maintenance issue, the fact that it is on a list of 30 high-risk concerns should have raised a red flag.

Mr. O'KEEFE. Senator, if I might, I want to disagree just a bit with the assertion that there were not—there was not enough dialogue or exchange or whatever else during the course of this. There was plenty of that. And ultimately, there is accountability. There

are people that can be identified very clearly as to who makes decisions about this during the mission management activity during on-orbit operations. And they are very clearly specified in terms of how they make those choices. The audit trail was pretty clear on this.

Having said that, it is a judgment call. And what they came to was—and that is the hard part of this; this is a much tougher conundrum about this than any other aspect—it is not that the information was not available; it was analyzed and deemed to be within the context of safety-of-flight considerations. That was a judgment call. And you are right, there were several different high-risk items that were identified, and those were all identified as things that need to be treated; but during the course of operations every previous flight—and yes, indeed, that information was available that demonstrated and was reviewed during the course-of-flight-readiness reviews and so forth—but determined to be not a safety-of-flight risk consideration. Needed to be fixed, but not something that would compromise the mission.

You know, last June we shut down the operations of the Space Shuttle program for the better part of 4½ months after identification of a hairline fracture in a fuel line. Now, that was determined to be a safety-of-flight consideration on those kinds of high-risk issues; therefore, stop everything until we fix that. And that is the difference. In some cases—there are all kinds of different abnormalities that you will find on every commercial aircraft, on any military aircraft, no matter what it is, that are requiring of corrections, but not determined to be safety-of-flight. That was a judgment call; and we will find out, in this investigation, whether that was an accurate judgment call. And certainly there appears to be plenty of doubt on that.

Senator SNOWE. If the photos had been able to show damage to the carbon-carbon leading edge that Senator Wyden was referring to, would anything have changed?

Mr. O'KEEFE. Absolutely. No question. If there had been something, any evidence at all, to suggest that there was a safety-of-flight consideration, it would have gone to, you know, five-alarm-fire status where everybody would have been absolutely beaten to parade rest every possible idea of how to correct the problem. There would be nothing left.

Admiral GEHMAN. Senator, may I comment?

Senator SNOWE. Yes.

Admiral GEHMAN. The Board is probably going to spend a good fraction of the time or the, you know, the linear inches of our report on this subject, and we have looked really hard at the question that you asked, Why do we have all this dialogue going on, but no transmission of any messages? And there is all this talking, but nothing is being transmitted.

And the Board is taking an interesting approach to this, and that is—the approach is that if you look at the O-rings on the *Challenger* and you kind of backtrack on how that decision failed to get made, and if you take the foam and the photographs in the *Columbia* and you backtrack and you say, "Oh, look, they missed something," we find that to be kind of unfair, because hindsight is wonderful. So the Board has said, "Let's look through all the waivers

and all the anomalies and all the steps that NASA has waived on all the flights and see if there are other items like this in which we continuously have these waivers and the acceptance of anomalies, and are there other things like this going on? And is it symptomatic of some process which is not working very well?" Because to pick these two incidents and work backwards does not take a whole lot of introspection; that is pretty obvious.

So the Board is interested, Are there others out there? And if there are others out there, how did they come to be accepted? How come we are still flying?

We have found others. And what we are doing is, we are trying to find out whether or not there is a process flaw which is not allowing safety items and engineering items to get up to the level that they should. We find that to be more intellectually honest than to go back and thrash people for what they should have seen on this one, and we have found what we believe to be some good analysis and good data which will help this process in the future, not just beat up on people for the past.

Senator SNOWE. Yes, I could not agree more. And I think looking prospectively and addressing the root causes is important so that it does not happen again—I agree.

Thank you.

[The prepared statement of Senator Snowe follows:]

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

Thank you, Mr. Chairman. America and the world was shocked and deeply saddened by the loss of *Columbia* in the skies over Texas on the morning of February 1. My thoughts and prayers *continue* to be with the families of the seven brave astronauts who lost their lives that day.

It is my hope that this hearing today will honor the memory and the service of the *Columbia* crew by aggressively investigating the events leading up to that tragedy to improve the safety of all future missions.

Clearly, many questions remain unanswered for all of us, and I hope that the Columbia Accident Investigation Board will continue to pursue all avenues to find answers. As we go through this process, we have an obligation to determine not only the circumstances of the actual event that caused the Shuttle *Columbia* to break up, but also the root causes behind that tragic loss. In doing so, we must look at our space program in its totality to identify any systemic breakdowns—from management structure to funding requests to potentially outdated equipment to pressures on the system resulting from the International Space Station program or plans to create a new orbiter, so we may remedy these problems to ensure we don't relive this tragedy.

At our Joint Hearing on February 12, I asked why military telescope imaging had not been requested in order to assess the damage that the *Columbia* Shuttle might have suffered from the foam debris that hit the Shuttle soon after liftoff. At that time, I was told that NASA had decided this imaging would *not* have been useful or necessary, even though similar imagery had been requested on previous missions. Furthermore, relying on computer models and past experience was described as the best way to assess the potential damage.

Since that time, we have learned that there actually was considerable division within the ranks of NASA regarding how important the debris hit might have been to the Shuttle's integrity. We have heard reports that at least two requests were placed for images, but that these were unofficial and not considered a high priority. It has been reported that at least one of those requests was cancelled because it did not come through the proper channels. So I come to this hearing very concerned about NASA's decision-making environment, and believing that the process has to be significantly altered.

At our February hearing, the actual cause of the *Columbia* accident was unclear. Now, through the tireless efforts of the Accident Investigation Board, we have a high degree of confidence that the Shuttle entered the earth's atmosphere on February 1st with pre-existing damage to its left wing—that this damage allowed the

hot gases of re-entry to enter the Shuttle and destroy it. Although the Board cannot guarantee that the foam debris that hit the Shuttle during lift-off directly caused the fatal damage to the wing, it seems likely there was a connection. While I am sorry that these tests are being performed *after* the *Columbia* loss rather than *before*, I look forward to hearing the results of the tests currently underway to investigate the extent of damage that foam debris hits can cause.

While the Board has learned a great deal in the past few months, at this point, we still don't have a detailed picture of *all* the factors that contributed to the loss of *Columbia*. So we cannot ignore any potential culprits—we cannot take any issue off the table that might have contributed to the accident. It is crucial that we obtain a complete picture of all of these factors and maintain our patient resolve regardless of the broad changes these findings might require before resuming Shuttle flights.

We must scrutinize what was done and what was left undone . . . decisions that were made during the two weeks of the Shuttle mission that we now question . . . and whether, more broadly, the competition between short-term and long-term goals has required trade-offs for years—trade-offs which contributed to this catastrophic event. We must inspect the tension between these priorities to help us determine the extent to which the *Columbia* disaster holds implications for our future goals.

As I have said in the past, space travel will always be an inherently risky endeavor. But we should never stop asking ourselves how we might best reduce the risk. Our intent to move forward with the exploration of space must also be accompanied by an unwavering, unrelenting, unceasing commitment to safety—and today I hope will mark an important step in that journey.

Again, thank you Mr. Chairman. I look forward to hearing of the most recent progress of the Columbia Accident Investigation Board.

The CHAIRMAN. Senator Breaux?

Senator BREAUX. Thank you, Mr. Chairman, and thank the witnesses.

I have two points. First is, it seems that a great deal of the investigation leads to the conclusion, I guess, that damage to the leading edge of the left wing caused part of the problem. The question then becomes, what caused the damage to the leading edge of the left wing? And the speculation has been that the foam coming off at the time of the launch hit the leading edge and caused some deterioration to the panels. And I know that you all have been testing that theory by some type of a mechanism that threw or shot the foam towards the leading edge to see if it could possibly do that type of damage. What can you tell us about the results of that test so far?

Admiral GEHMAN. Yes, sir.

The testing started last week. We are, indeed, shooting pieces of foam at test articles that are orders of magnitude larger than ever been done before. This testing has been going on for years and years and years. But the shots have always been tiny little pieces of foam at tiles and all that kind of stuff. And, of course, that then leads to this erroneous analysis of how much damaged the tiles, but that is another story.

We started by shooting foam at—once again, this was the first time that foam of the size that came off this time has ever been used as a test. We started shooting at the wheel well doors, because, as you may recall, six or eight weeks ago we suspected that the heat was getting in through the wheel well door. The recovery of the onboard recorder changed all that. We are now building a leading-edge test target. That will not be ready until the first of June. The first couple of shots that were conducted by Southwest Research Institute were very, very mild, angle-of-impact kinds of shots. Little or no damage was done. The angle of impact under-

neath here was much shallower than was actually experienced in real life. As we start to crank the angle of impact around, the damage gets much more severe, and that is the testing that is going on now. We are just now getting——

Senator BREAUX. That is damage on the bottom?

Admiral GEHMAN. To the tiles. To the tiles.

Senator BREAUX. To the tiles. On the body, not the leading edge?

Admiral GEHMAN. That is correct. We have not started shooting at the leading edge yet. We will start shooting at the leading edge, to get to your question directly, around the 1st of June.

Senator BREAUX. But the results of the tests on the tiles on the undersurface of the Shuttle indicated much more damage than had been experienced before in the test?

Admiral GEHMAN. The damage is dependent on the angle of impact. And as we get up into angles of impact which are representative of what we think really occurs to the Shuttle, the damage is more severe than previously thought. That is correct. It is dependent on the angle of impact.

Senator BREAUX. Mr. O'Keefe, how many times in previous launches has foam insulation separated from the fuel tank and broken off in launch or at other parts of a mission?

Mr. O'KEEFE. There were four observable events that were recorded and analyzed as a consequence—going back to, I think, STS–7, I think, was the first one. There were several other events of smaller pieces, apparently, that were documented, as well. But the ones that were significantly analyzed were these four different events, the most recent of which was on STS–112, which was launched in October.

Senator BREAUX. Are there any reports anywhere in NASA that raised a serious concern, a red flag, alert, that this was a problem or could be a more severe problem?

Mr. O'KEEFE. I think for the reasons Admiral Gehman just described, there were tests that were conducted thereafter that led engineers to conclude that the impact was not—on those four significant events, was not considered a safety-of-flight compromise.

Admiral GEHMAN. Senator, may I——

Senator BREAUX. Yeah, any comment on——

Admiral GEHMAN.—I will respectfully disagree with the Administrator, here. Foam coming off the external tank has hit every flight on every orbiter. If you want to measure total number of hits, it is thousands. If you want to measure hits that have caused damage to the tiles of greater than an inch, it is about 30 per flight.

What the Administrator was referring to is this particular piece of foam that we are talking about in this instance, which is a special piece of foam molding that is hand-molded to cover a certain connection point called the "bipod." That particular piece of foam is known to have come off six total times, including this flight, but there are over 40 flights for which we have no information—for example, the ones launched at night or ones where we could not photograph the external tank when it comes away. So there are six that we know of, out of 40, minus 113, minus—out of 70-some flights.

And so, just to make the record straight, this particular big piece of foam, the Administrator is right, only half a dozen times; but foam hitting the orbiter occurs on every single flight.

Senator BREAUX. Well, I mean, I think that is a significant piece of information for everyone to understand. I cannot draw any conclusions in my own mind, but it seems to me that that might be the smoking gun. And the fact is that this is not the first time it happened, but that insulating foam was coming off on every flight, and that, on thousands of hits, damage to the tile had occurred. It just seems to me that it was only a question of time when one of those hits did the damage that ultimately was done to the *Columbia*.

Thank you.

Mr. O'KEEFE. Senator, if I could. Again, I do not disagree with Admiral Gehman at all. I apologize for having understated this at all, because it is a very significant event. There is no doubt about it. I was referring very specifically to the bipod section, and Admiral Gehman is precisely right, this is how it has happened in each and every case. And I do not want to understate this.

The question that is really being debated internally in NASA right now is, Why did we permit a process that would tolerate any strike? That is the really important factor, I think, and we are really going through a soul search now saying, What is it that contented ourselves to believing that any strike should have been tolerated? And that is a much deeper-process issue that really is being examined, and there is a lot of real soul search going on that says, we rationalize based on historical evidence of what we thought was acceptable damage. Why would we think any level of damage would be deemed acceptable?

Senator BREAUX. Well, I mean, you have just put your finger on the real question. You know, if it had been one hit at one time——

Mr. O'KEEFE. Uh-huh.

Senator BREAUX.—I think someone would be justified in saying, "Well, you know, it happened once out of thousands of flights." But it happened thousands of times, and this was probably the last time.

Mr. O'KEEFE. Yes, sir.

Senator BREAUX. Thank you.

The CHAIRMAN. Senator Brownback?

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

Senator BROWNBACK. Thanks. Thank you very much, witnesses, I appreciate the information you are putting forward.

Admiral Gehman, has the commission come up with any ideas on changing the decision-making process to see that a mistake that had been made in judgment this time around—Mr. O'Keefe has already said that we clearly should have gotten imaging and there was a mistake in judgment made—has the commission come up with any recommendations to change the decision-making process yet that they are willing to put forward?

Admiral GEHMAN. Senator, we have not come to any conclusions yet, but I will predict that probably a third of our report is going

to be on this subject, because we believe that is really the lasting and the significant legacy that we can leave here.

Yes, indeed, we think this is a systemic problem, that if you just change the people or change the names of the committees, it will not do any good, that there actually is a process problem here. And we have opinions on how to go about this. We have availed ourselves of literally dozens of experts in the area of safety engineering, risk assessment, risk management, high-reliability organizations, in order that we can write authoritatively on this subject.

I will add, also, parenthetically, that you—in our opinion, neither the Congress nor this Board could get at these very, very deep-rooted institutional problems unless we availed ourselves of the investigating technique that is associated with a safety investigation, in which people can speak without being in fear of retribution.

Senator BROWNBACK. Well, who was responsible for the mistake in judgment this time around, particularly on the imagery? You said, I think, clearly, "Well, okay, there was a mistake in judgment made. We should have gotten imagery." Who made that determination? Who was responsible for that decision?

Admiral GEHMAN. I would not characterize that decision as a mistake by any one individual. When you have got an organization which is run by boards and committees, and those boards and committees do not work, I am not sure you can blame an individual person. So I will have to duck that question. I can tell you which Board or committee did not work as designed, and I can tell you why——

Senator BROWNBACK. Well, which one did not?

Admiral GEHMAN. In my opinion, because the Board has not spoken on this yet, in my opinion both the boards that assess the condition of the orbiter before it is launched, which are boards and committees set up by the program manager, and the boards and committees that run the mission after it is flying, are ill-served by an imperfect system of checks and balances. And by that I mean specifically the safety organization sits right beside the person making the decision; but behind the safety organization, there is nothing back there. There is no people, money, engineering, expertise, analysis. The engineers sit right to the other side of them. But the engineering department is not independently funded. The engineers all have to charge to a program or something like that, so their allegiance is to the program. And we find that to be an imperfect system, and the boards are ill-served, and you are going to get the same wrong answer no matter how many times you convene those Boards. And it does not make any difference who the chairman is.

Senator BROWNBACK. Well, now, this is a very troubling point that you make, that you are going to get the same——

Admiral GEHMAN. Wrong answer.

Senator BROWNBACK.—wrong answers? Why are we going to get the same wrong answers? These are good people. They are all well-meaning people. Why are we going to get the same wrong answers?

Admiral GEHMAN. Once again, I am kind of a little bit out in front of my headlights here, because the Board has not completely spoken on this. But giving my own personal view of it, we have availed ourselves of a very, very rich and deep academic world, who

studies these kinds of things, as well as industry, like nuclear power plants and petrochemical plants and things like that about, How do they do safety, and how do they build in checks and balances so that the people who are making decisions are getting good, contrary opinions? And to us it seems that this is the flaw in the system, that unless you change the management techniques and unless you change the procedures, you can change the people sitting at the seats and they will still not give good advice.

Senator BROWNBACK. Well, what you are describing to me is a committee without a head or a process without a design——

Admiral GEHMAN. No, I——

Senator BROWNBACK.—that just communicates a lot back and forth, that there is not a responsible point at which a person is responsible for the decision-making?

Admiral GEHMAN. No, sir, I would not agree with that. There is a Chairman, and there is someone responsible, and everybody knows who that is, but the process is not serving that person very well.

Senator BROWNBACK. How is the process not serving that person? Specifically how is the process not serving that person well?

Admiral GEHMAN. Because the key advisors, the people who would bring up alternative points of view, the people who would say, "Wait a minute, this is not safe," or—they are in the room, but they are not supported by—they can't come and argue their cases with 18-inches worth of documentation, because they are not funded well enough. They are not independently funded. There are not enough people in there to do that independent research in order that they can come to the table and make a persuasive argument. They are kind of there by themselves.

Senator BROWNBACK. They are there without backing, I guess?

Admiral GEHMAN. They are there without backing. And when you get into these very technical issues about whether this is safe or whether or not this signal is important or whether or not this little anomaly needs to be paid attention to, you have to come with data. These are engineers. You have to come with facts and data and studies. You cannot just get in there and wave your arms and beat your breast. You have got to come armed with ammunition.

And so the safety—we find the safety organization is, on paper, perfect. But when you bore down a little bit deeper, you do not find any "there" there. And the engineering department looks precisely organized exactly right, but then when you go bore down and find out what these 600 engineers are doing, you find that three quarters of them are funded by the program, and so you know where their allegiance is, et cetera.

So we are going to try and make some recommendations to improve the process of safety, but do not mislead, do not—that is why I am giving you this unsatisfactory answer, and I know the Chairman is still looking at me—but that is why we are trying to find a way to fix this and fix it right. But it is not necessarily any individual one person's responsibility.

Senator BROWNBACK. So you need internal muscle that is separate and distinct from the program that can effectively argue within the structure—for the change that we need to be addressing. Is that correct?

Admiral GEHMAN. That is correct. And now the Board is loathe to make specific organizational and management recommendations for the fear of the law of unintended consequences. We are not going to be around to manage these things and steer them. But I believe that when we write our report, we are going to give quite direct and specific guidelines on how this process ought to operate.

Senator BROWNBACK. Thank you, Mr. Chairman.

Mr. O'KEEFE. Mr. Chairman, may I comment very briefly?

The CHAIRMAN. Sure.

Mr. O'KEEFE. In this——

The CHAIRMAN. Could I comment first? When I was a young lad, the U.S.S. MISSOURI ran aground not too far from here. The captain was asleep in the cabin, and the navigator ran it aground. The captain was relieved immediately. But now, since there seems to be an interesting situation, no one is responsible. No one is responsible because we are all responsible; so, therefore, no one is responsible. No one is responsible for 9/11. No one is responsible for Khobar Towers. No one is responsible for a whole bunch of other things, bad things, that have happened. We are all responsible; so, therefore, no one is responsible.

Go ahead.

Mr. O'KEEFE. Thank you, sir. No, thank you, Mr. Chairman. That is a perfect prelude to my respectful disagreement with my friend, the Chairman of the Columbia Accident Investigation Board. There is no ambiguity on who is responsible. There are two folks who sit at the flight readiness review. The Associate Administrator for space flight and the Associate Administrator for safety and mission assurance. They sign the order that says, "We certify this is ready for flight." The argument that is being advanced here is that the quality of advice they are receiving, in the opinion, I think, of the Chairman of the Columbia Accident Investigation Board, needs further support. That is a point that we have positively got to look at. But in terms of who is responsible, there is no question about it who signs the certification on this case. There are identified, named individuals who are part of this mission management team.

Senator Snowe asked the question, "How many people participate in that?" Lots of engineers and so forth. You bet. Lots of folks participate there. But there are specified folks, with name, faces, serial numbers, and, you know, pay checks that are provided that are chair of the mission management team and members of it that make determinations and are responsible for that.

There will be accountability here. There is no question about it. This will not be ambiguous about who is responsible at the end of the day. We are awaiting the report. There are certain changes that have to be made. But, in the end, there is no line or argument of a mush-mouth system here of how these decisions are arrived at. There are individuals who you can identify and say, "That is the responsible official." And I think the point that has been made here is, the quality of the advice that is being rendered to them may not be as organized as it should be.

My attendance at flight-readiness reviews in prior flights, to include, you know, most recently, I guess, 113, was—you look in this room, and everybody and anybody who has an opinion on the qual-

ity of the readiness of the orbiter to fly are in that room. It is a big confab. And anybody has got the opportunity to step up and speak. And many of them are the functional equivalent in the space flight community of E.F. Hutton; whenever they stand up, immediately everybody recognizes them and they stop everything until the issue is resolved. In the end, that judgment has to be rendered by two people, and that is very clear in the way this process works.

Same is true during an operational mission management team. And the issue, I think, that Admiral Gehman is raising is, What is the quality of that advice, how is it organized, and how do we make it more relevant for them to make the kinds of decisions they are asked to make?

Senator BROWNBACK. Mr. Chairman, could I respond to this, because I want to bore in on this point, and it does seem to be a very important one. What I hear the Admiral saying is, that there is not a muscle, an independent muscle, behind that is challenging this process internally, that the people, the engineers and the others that are commenting are part of one a systemic system all funded from one system, and it needs an independent muscle that is there in the room that can speak from engineering data and specifics. They can challenge the decision-making process. Is that correct, Admiral?

Admiral GEHMAN. That is correct. And, by the way——

Senator BROWNBACK. If I could, then——

Admiral GEHMAN. Yes, that is correct.

Senator BROWNBACK.—if I could.

Administrator O'Keefe, I am not here trying to point fingers, but I am trying to figure out how we keep this from happening again. We do not want anybody to die. You do not want anybody to.

Mr. O'KEEFE. Sure.

Senator BROWNBACK. Do you agree with that assessment, that there is not the independent muscle behind the challenge process internally in making these safety and engineering decisions?

Mr. O'KEEFE. Again, I am guided by the view of the Board. If their view is that it is inadequate, that is the answer, it is inadequate, and we will go fix that.

Senator BROWNBACK. Thank you.

The CHAIRMAN. Admiral Gehman, did you want to make an additional comment?

Admiral GEHMAN. Thank you very much.

As I indicated, we, on the Board, have grounded ourselves, we think, in aerodynamics and thermodynamics and physics to the point where when we write on what caused this accident, it is unlikely that we are going to get challenged on any of our findings. In order for us to write on this subject, we have had to ground ourselves in what we, in the United States, know about these very complex management techniques. And so we have done that, to a great extent.

And two of the principles that have struck me get to the point where, indeed, the person who is the Chairman of this Board or the Chairman of this Committee or the two people who have to sign the paper, they are identified by name. We know who they are, and you know who they are. But so many of these experts in this area

have told us that just picking on those two people and firing them or something like that will not prevent this from happening again. If you have got a flawed process, the next chairman is going to make the same mistake, probably. So we are quite driven by that.

The second thing that we are quite driven by is writing out of a report that I would like to acknowledge other people here, but the writing goes along the lines of this. This way. That the wonderful engineers who give us all these magical things also make a pact with the devil—I am thinking of things like nuclear power plants and petrochemical plants and dams and things like that—that you get all the—and Space Shuttles—you get all these magical things from engineers, but the pact that you make with the devil is you have to be vigilant forever, because now you have got this dragon by the tail. And it could be that in the 25 years or 20 years of this program, as the conditions of Shuttle life change, the Board is looking at whether or not this vigilant-forever law has been observed, or somehow have we migrated away from that? And the Board is going to try to write on that.

Senator BROWNBACK. Very good.

The CHAIRMAN. Senator Nelson?

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

Senator NELSON. Thank you, Mr. Chairman.

Senator Brownback, I want to pick up on your line of questioning. But first I want to say, Admiral, thank you for your public service. Thank you for the public service that you rendered, even after your retirement, with regard to the U.S.S. COLE investigation. Thank you for your public service for this. And it is this Senator's hope that you are going to succeed, and that is what we want to see, that you succeed.

In the line of questioning from Senator Brownback and in your response earlier with regard to the safety process that had been set up 17 years ago, and your quote was, "There is no 'there' there." Now, that makes my blood boil. Because of the communication problems 17 years ago with *Challenger*, which it, in large part, was—that was the reason for the destruction of *Challenger*, that information could not flow from the bottom up; it was much easier flowing from the top down. And so this process of safety was imposed, and the safety process was supposed to be an automatic failsafe. But you say "there is no 'there' there."

Why do you think we have not learned the lessons from *Challenger*, as painful as that was?

Admiral GEHMAN. Senator Nelson, thank you very much for the vote of confidence. We will see whether or not that is well founded or not. But the Board is going to spend an enormous amount of energy to answer that very question.

It is possible—it is possible—that we have the system that we have right now because of *Challenger*. There were recommendations to consolidate, have a more formal chain of command, have a more strict and monolithic program, that were part of the *Challenger* recommendations, and, once again, I do not want to get ahead of myself, but we are going to look at this in great detail.

We have also looked at best-business practices from other very, very risky communities and have found how they do high-reliability kinds of things, and the Board will attempt to write an outline that will ensure that these kinds of safety issues do, indeed, get raised at the right level and then the people who have to make the judgments are advised well and these issues are not submerged.

I do not want to get into anymore detail than to say that, at this time, the preliminary—at this stage in our report, I am willing to volunteer that we are not completely satisfied that underneath the box that says "safety" and "S and MA" that there is a big, robust organization which allows the person in the box to come to the table with the same number of chips as everybody else. And under the box that says "engineering directorate," that there is not enough independent good old engineering kind of thinking that NASA used to be known for to come to the table and bang on the table and say, "You are wrong, and I can prove it."

That is about as far as I am willing to go at this time.

Senator NELSON. All right. Let me nail down something that the Chairman and Senator Hollings said earlier, asked you about, with regard to our congressional oversight.

Admiral GEHMAN. Sure.

Senator NELSON. I need to know, specifically for the record, since you are trying to protect the identity of the witnesses, since you want to encourage people to come forth and tell the truth without having to subpoena them for the truth, understandably, you want to protect their identity. What we need to know, is that testimony, that full testimony, available to this Committee in our congressional oversight capacity?

Admiral GEHMAN. The answer, the short answer, is we are in the process of working out an arrangement by which you will have access by some process to all that information. The answer, the short answer, is yes.

If I may just say that the purpose of giving witnesses guarantees of anonymity is not so they will tell the truth. That is not the issue. They will tell the truth when they come up here and raise their hand. The purpose is to find out things that they would not volunteer under questioning. That adds a whole different range of information, a whole different body of insights in which they may say something that they are not fully sure of, for example. They just—or it is a feeling that they have or something they cannot prove or something like that which they would not give to anybody who was doing this in a public forum.

Senator NELSON. Well, there was some question in Senator Hollings' mind. I am glad that you have clarified that, that the answer to the question is yes.

All right, let me comment. I happen to agree with your statement about the old-timers, that the old-timers basically, if they knew there was the potential of a problem, they would have started working it. They would have done photos immediately. They would have started pulling out of their hip pocket every possible theory of changing anything that could be changed, as well as what Senator Hollings had said, "cold soaking," no roll reversal to the left, maybe a different angle of attack.

What do you think? Why did NASA and its leaders tolerate—I guess the question is, What is your report going to tell about re-enacting this of how you would do it pursuant to the old-timers?

Admiral GEHMAN. The old-timers certainly taught me something, which I find compelling. In the business about photos, for example, on-orbit photography. They would say, "It doesn't make any difference whether you could have done anything to save this crew or not, we would have taken photographs just so we would have known what happened." I mean, the old-timers have a more flight-test, test-pilot kind of attitude that even though the loss of a crew is terribly regretful, if you have a test-pilot kind of an attitude, you always want to know what happened so that they did not die in vain. So, of course, they would have taken photographs. You would not have had to prove that there was a foam strike. All you have to do was scratch your head and say, "Hey, I don't think I know what happened here," and the next thing all the lights would have gone off.

And so that is compelling to me. In other words, you do not have to prove that somebody made a mistake, or you do not have to prove that an error in judgment was made. The old-timer attitude would have got you photographs "just because." And maybe we could not have done anything about it, but we would have—maybe we would have known what happened in this particular case. It is more of an intellectual inquiry kind of an attitude.

Senator you were not in the room when I mentioned earlier that we and NASA have just begun, ten days ago, a very in-depth and aggressive analysis of what could have been done. And I mentioned that we could not have done this earlier because there were too many emotions. Everybody was too close to it. But now that we have got a little time separated and we, the Board, know a little bit more about this, together we are looking very, very hard at what might have been done. But I do not really know that even if we find an answer, you know, put duct tape on it or something like that, I do not know that it is going to result in whether or not—that it can result in whether or not we could have saved this mission or not. I just do not know.

The only thing I do know, and I know that the Administrator agrees with me, is that we would not have done nothing. I mean, that is not the way we do things. We would have done something. And even if we only had a 10 percent chance of saving this, we would have—there were two EVA suits on-board; they could have gone out and taken a look at it, they could have put duct tape on the thing—I mean, I do not know, I am just making that up, of course. But they would have done something.

The CHAIRMAN. Senator Sununu?

Senator SUNUNU. I thank you, Mr. Chairman.

I want to begin by exploring this issue of accountability that the Chairman raised. Admiral, I think you said that, something to the effect, you do not want to "pick on" those that were responsible for signing off on the flight security, because if there is a flawed process, even if you have a replacement, you will still have a flawed process.

And I would maybe differ with that just slightly. The Chairman used an example of the U.S.S. MISSOURI, I think, that ran

aground. Now, I do not know that they changed the process or not, but my guess is not only did the subsequent captain not run aground, I bet the Missouri never ran aground again.

So we do not want to single anyone out inappropriately. We want the criticisms to be based on good information, good analysis. But I do think there is something to be said for a system that does hold those in a position of responsibility accountable, even if there is a flawed process and even if you are not sure you have implemented a perfect process, because a system that holds individuals accountable will create an incentive for those in a position of responsibility to do everything possible to make sure the support systems, the processes that help them make decisions, are good ones. Would you agree with that?

Admiral GEHMAN. I think you—I support your comments completely. I come from a system that is the way we do business. And I have no problem whatsoever with the process, the Administrative processes, of NASA and the Congress and the Administration, of taking whatever steps are necessary if you think someone's performance was lacking. It is just not the function of this Board.

Now, you will be able to tell from my report where to go looking. We are not ducking the issue. It is just not the function of this Board. The function of this Board is to try and make space flight safer, to find out what happened and try to make space flight safer in the future if we can. And we believe we will be able to do that for you. And if there are—if we found that someone had not executed their duties in accordance with NASA regulations, we will note that. But that is not the purpose of this Board.

Mr. O'KEEFE. Senator, if I could. I think at the conclusion of this investigation, when this report is finalized and after the agency takes said actions to implement those findings, I am confident you will find no ambiguity on this question of accountability at all.

Senator SUNUNU. Excellent, thank you.

Senator Breaux, in his line of questioning, talked about the foam insulation breaking loose, and I want to be clear on what you said. I think you indicated that there had been 30 impacts, approximately 30 impacts, that had resulted in a specific amount of damage.

Admiral GEHMAN. One inch.

Senator SUNUNU. One inch? Or I take it that is one inch or greater.

Admiral GEHMAN. One inch or greater.

Senator SUNUNU. And——

Admiral GEHMAN. Sir, excuse me, per flight.

Senator SUNUNU. There have been an average of 30 impacts per flight that have resulted in damage of one inch or greater. And can you describe—when you say "damage of one inch or greater," can you give us a little bit more background or detail as to what type of damage that is and what part of the Shuttle?

Admiral GEHMAN. Yes, sir. It is on what we call the "acreage tile," the 25,000 individual tiles, like this. And we are talking about a divot, a chip, that is greater than one inch in any dimension. And underneath this black is white, so if you chip this, it is pretty obvious. So a chip in the tile anyplace on the orbiter in the thermal-

protection system that has a dimension in any direction of greater than one inch.

Senator SUNUNU. Thirty, an average number or——

Admiral GEHMAN. Thirty is an average number.

Senator SUNUNU. And talk to me a little about the standard deviation. Did it vary greatly from flight to flight or——

Admiral GEHMAN. There were——

Senator SUNUNU.—was it pretty consistent that you would have 30 impacts of that nature?

Admiral GEHMAN. With the exception of four or five flights in which there were tremendous variations, up in the hundreds, and these were accounted for—for example, when NASA changed what we call the "blowing agent," the air power behind the foam application, in accordance with EPA regulations to stop using freon, on the very next tank that flew with the new blowing agent the number of divots was up in the hundreds. They immediately knew what the problem was. They changed blowing agents. It had gasified in a different way that they had not anticipated. So they fixed it, and the next time it went back down to 30, just like that.

I would also tell you, Senator, that the trend over all 113 flights is flat, not getting any better.

Senator SUNUNU. There seems to be, or have been, a process to measure and quantify the damage from these impacts. Was there any process, albeit unsuccessful, from your description, to address or reduce the number of impacts?

Admiral GEHMAN. There have been steps taken. There have been discussions, meetings, studies, analyses to reduce it. Unsuccessful. And while our audit—we call it an "audit," because—we call it "following the foam"—there is a foam audit going on right now, all the way from the first flight, trying to go through the records to see what the records say that these various boards and committees did to adjudicate, "What should we do about the foam?" And, generally speaking, the records kind of just die off. What I mean is that the issue just kind of goes away. It is never actually really addressed in an engineering point of view.

Senator SUNUNU. When did it go away?

Admiral GEHMAN. What happen is, is that the foam hits the orbiter, there are a couple of significant issues, it appears on the FRR, the flight readiness review, and various material Boards, they study it real hard to see what they can do about it, they have four or five more flights in which there are only minor problems, and they say, "Well, looks like it is not a big problem." And then what happens is that success clouds their engineering judgment. They say, "Well, look, it is still happening, but nothing bad is happening. It looks like it is okay." Then another couple of years will go by, and something big will happen, it will appear in the records again, some studies will be ordered, some engineering analysis, maybe a fix, and then the number go back down to reasonable numbers, and success again breeds this attitude that it looks like it is okay.

Senator SUNUNU. But it is fair to say the average number of impacts over the last, just say, 20 flights was relatively constant.

Admiral GEHMAN. All the way from the first one, it is relatively constant.

Senator SUNUNU. Throughout, the issue of space debris was raised during just some of the early press accounts, guesswork, hypothesis, you know, of what might have happened. I assume that has been reviewed pretty thoroughly by the Board. Is that concern or question still a possibility as a cause of damage or perhaps something that made existing damage worse while in orbit? And on a related note, have you learned anything or come to any conclusions about our ability to track and to deal with the threat of space debris to future flights?

Admiral GEHMAN. The issue of the possibility of the orbiter being hit by space debris is unresolved by the Board at this time after a lot of work. The Board understands the ability of the United States to track space debris down to a certain size, and the Board understands how the orbiter is maneuvered around the intersection—you can call "conjunction"—with space debris down to a certain size. But then micrometeorite, the little, tiny stuff that we cannot track, that we do not even know is out there, remains an open issue.

And we have attempted to get at this issue by a number of very clever ways. The orbiter has some very, very sensitive accelerometers on-board the output of which is recorded on-board and not "telemetried" down to earth. It turns out that the recovery of this data recorder, which is a miracle, has allowed us to read out those accelerometers. There are a couple of little jiggles in some of those accelerometers, which would suggest that we need to look harder at that. But we cannot rule out a tiny little micrometeorite kind of a strike.

Senator SUNUNU. My final question for the——

The CHAIRMAN. The time has expired.

Senator SUNUNU. May I ask just one final question?

The CHAIRMAN. Go ahead.

Senator SUNUNU. And I think it is a short answer. In hindsight, or looking back to the very first few days of this investigation, which was a difficult time for so many people, is there anything at this point that you would look back and say, "You know, in hindsight, in the first few days, I do wish we had taken a particular step or structured things slightly differently or taken some time, you know, to facilitate a particular task," anything that you could identify, Administrator?

Mr. O'KEEFE. I guess, as a personal and professional philosophy, my attitude is make the best decision you can based on the information you have at the time and move on and continue to progress. I do not spend a lot of time thinking back to what we mighta, coulda, shoulda, woulda. I think it is as professional and as straightforward a process as I know how to do, and it was within hours that not only the NASA team, but also the Columbia Accident Investigation Board, was empaneled and the investigation began immediately. Everybody followed a contingency plan that I had personally reviewed several times, in the event something like this could happen, and was very content that starting at 9:29 that morning, the first action item on that contingency plan was actionable, and we followed the procedure exactly the way we had talked about it. Secure in the knowledge that we would likely not ever

have to use it, we, nonetheless, had to, and I just cannot look back on that and really revise the history of it.

If I could, very quickly, Senator, just observe one point, I think, in the discussion here that you have had on the strikes. This is the—the tile damage on each and every flight—Admiral Gehman has got it exactly right—some of it comes from foam strikes, no question about it. And there are many other things that will also damage the tile. Of those 25,000 tiles that are aboard, as soon as every orbiter has landed, the first thing the commander wants to do first, and Senator McCain will appreciate this, is you want to make sure that the wheels are right on the center line of the runway. That is the first obsession on the part of every commander. The next step, though, is to walk around the orbiter and observe every one of these strikes. And there are lots and lots of streaking that occurs on the tiles.

And based on the condition of those tiles, they are either replaced or repaired in between flights, and the issue that I think Admiral Gehman was talking about—so, in other words, there are a lot of contributing factors; not just foam, but plenty of other incidents that will occur on orbit or on re-entry that will create a visible kind of damage to the tiles on-board the Shuttle itself. And each of those are either replaced or repaired.

But the issue I think that Admiral Gehman is raising that really, really is a point of deep consternation with us right now, that we are really doing a lot of soul searching about, is there are certain aspects of this that were tolerated because it had this exacting kind of "no unusual circumstance out of the norm." And so what academics are referring to is the normalization of deviation, as in "if you see it so many times, you finally consider it to be an acceptable condition," is the issue. That is the point we are really doing some deep soul search about.

And as we talked about earlier, why we ever got into a position where we tolerated anything greater than zero on this is the point we are really debating among ourselves right now and trying to determine how we can create a system that would never tolerate that kind of circumstance again. And it is not just foam; it is the range of things that could tell you, in a trend, what could potentially become a deep compromise to safety-of-flight consideration. That is the deeper issue that I think is being raised by the Board, that we are hearing in public testimony, we are hearing supported, and we are clearly seeing evidence of that concern, and we are wrestling with, How do you adjust that process to assure that kind of understanding in the future?

The CHAIRMAN. Mr. O'Keefe, did you request $15.5 million for the Institute for Scientific Research in Fairmont, West Virginia.

Mr. O'KEEFE. No, sir.

The CHAIRMAN. How about $7.6 million for hydrogen research being conducted by the Florida State University system?

Mr. O'KEEFE. Not that I am aware of.

The CHAIRMAN. 2.25 million for the Life Sciences Building at Brown University, Providence, Rhode Island?

Mr. O'KEEFE. Not that I am aware of.

The CHAIRMAN. You will notice that each of these are geographically specific? How about $1.8 million for the construction of a Gulf

of Maine Laboratory at the Gulf of Maine Aquarium Foundation? Did you request that?

Mr. O'KEEFE. No, sir, not that I am aware of.

The CHAIRMAN. How about 1.35 million for expansion of the Earth Science Hall at the Maryland Science Center in Baltimore, Maryland? Did you ask for that?

Mr. O'KEEFE. No, sir.

The CHAIRMAN. I understand, also, you are paying for a bug exhibit in Chicago. I saw that on one of the networks. Did you see that?

Mr. O'KEEFE. I am not aware of it, sir.

The CHAIRMAN. And yet your budget has been largely flat.

Mr. O'KEEFE. I had a 3 percent increase last, and projected, if the Congress will tolerate, a 4½ percent increase this year that we hope for Congress' support.

The CHAIRMAN. I am talking about in previous years.

Mr. O'KEEFE. Yes, sir. Prior—yes, sir.

The CHAIRMAN. Well, in the issue of responsibility, Admiral Gehman, I hope that you will, in your deliberations, if there are programs, critical programs, that have been underfunded in this pork-barrel spending, which is in the hundreds of millions of dollars over the past few years—hundreds of millions of dollars—unrequested, add-ons, some outrageous, some not so outrageous, some of it may be good things, none of it requested—as I mentioned earlier, it went from, in 1998, from 24.7 million to 167 million in 2003—I hope that the Board, when we are talking about responsibility, will talk about the responsibility of Congress to spend these monies that are earmarked for NASA that are supposed to be for programs associated with NASA rather than pork-barrel spending and whether that may have impacted the funding of critical programs. I hope that the Board will be looking at that, Admiral Gehman.

Admiral GEHMAN. We will, sir. We are going to look at budgets, and $100 million will buy a lot of safety engineers.

The CHAIRMAN. Thank you. As I mentioned, last year it was $167 million, and some of it, it just staggers the imagination, has no more relation to—well, anyway.

I have one additional question for Mr. O'Keefe. We all know what happened to the Soyuz capsule, steep angle, 10 Gs, 300 miles away, no radio communications. Are you confident that that is a vehicle that should be used in this interim period? And if not, what are the options?

Mr. O'KEEFE. Certainly, this was an outside-the-norm landing pattern. It was an upgrade of the Soyuz capsule, and it was the first time that specific upgrade module had flown. The Rosaviakosmos, the Russian Space Agency, is conducting an investigation now. We are a participant, and we have got members who are involved there. We have got a significant team of folks who are resident in Moscow and in Star City, who are working with the Russian engineers to determine exactly how this particular abnormality occurred. But it is not outside the envelope of what would have been expected. A ballistic re-entry can and does occur. Very infrequently, but it did. And in this particular case, trying to deter-

mine exactly what caused it in this particular case is what our objective is all about.

Having said that, it has not posed a safety-of-flight, you know, factor, and it is not one that our outside folks, General Stafford and others who have reviewed the flight worthiness of the Soyuz, have concluded that it is a more than acceptable, flight-worthy craft for the purpose of the effort we are engaged in now to replace the International Space Station Expedition crews.

So our confidence is still very high. It was, no question about it, the better part of two-and-a-half hours of extremely anxious period and four hours before we were able to get a visual, look-'em-right-in-the-eye determination that, yes, everybody was okay. But all the commentary from—I met with all the crew immediately after they returned to Star City that day, and they found that while it was an exciting trip, it was not, nonetheless, something that they were untrained for. They knew that was within the envelope of how that happens.

The CHAIRMAN. Ten Gs is a pretty——

Mr. O'KEEFE. It was——

The CHAIRMAN.—interesting experience.

Mr. O'KEEFE.—really exciting. Yes, sir. No doubt about it.

The CHAIRMAN. Senator Nelson has promised me that he will take a maximum of ten minutes, realizing that you have already been here for well over two hours, and I appreciate his involvement, his experience, and what he brings to this Committee on a variety of issues, but particularly on this one. He is also a man of his word. Ten minutes.

Senator Nelson?

Senator NELSON (PRESIDING). Mr. Chairman, as long as they do not give ten-minute answers.

[Laughter.]

Senator NELSON. Mr. O'Keefe, were you aware of the piece of debris that left the Shuttle on flight-day one?

Mr. O'KEEFE. No, sir.

Senator NELSON. Who was aware? And would they have had a responsibility of telling you about that debris?

Mr. O'KEEFE. Let me give you a full list of all the people who were aware of that particular incident.

Senator NELSON. Make it short, because I have got lots of questions, and the Chairman wants to keep it short.

Mr. O'KEEFE. Sure. We will provide that for the record, sir.

Senator NELSON. Okay.

[The information referred to follows:]

In addition to the official in the Space Shuttle Program, the Associate Administrator for Space Flight, the Deputy Associate Administrator for International Space Station and Space Shuttle Programs, and the Associate Administrator for Safety and Mission Assurance were made aware of the debris hit and advised that the MMT had determined the event not to be a safety of flight issue. The Space Shuttle Program Manager was also notified that the no safety of flight decision had been made.

The Administrator is kept informed of any critical aspects of any NASA spaceflight mission. At this point in time during the mission where the foam debris was not defined as a safety hazard for the STS–107 crew, it was not necessary to notify the Administrator.

Admiral GEHMAN. Senator, the piece of debris orbiting the Shuttle on flight-day two was not discovered until six days after the accident. Nobody knew about this thing when the flight——

Senator NELSON. Thank you for sharing that.

Well, given the fact of the multiple thousands of hits from foam in the past, how far—did the safety people directly engage in a discussion about the foam hits?

Mr. O'KEEFE. I am advised they did, as recently as the STS–113 mission, which was the one immediately preceding 107. There was a discussion at the flight readiness review of the foam strike—of significance, the bipod strike that had occurred on 112—and they had reviewed that particular matter.

Senator NELSON. Well, Admiral, of course, that will be a main part of your investigation. Admiral, when do you expect your commission to issue a report?

Admiral GEHMAN. We are event-driven. I would characterize us as finishing up the investigation phase right now, and we are beginning the deliberation. We are going to move here to DC the first week in June and begin writing. It would be my goal, assuming that the Board can move along with me, to have our report delivered to you prior to the August recess. But I have to caveat that. That is my goal.

Senator NELSON. Are you contemplating that you are going to recommend that the vehicle should be fully recertified?

Admiral GEHMAN. I am afraid I am going to have to duck that question, because we have not got to that point yet. Every time we come to a conclusion about a recommendation, we issue it as soon as we can. We have a number that are percolating up right now, and that is not one of them.

Senator NELSON. And, of course, as I said at the outset, it is enormously important to us that you are successful in this and that we can get on and get the thing fixed and start flying again. Now, in view of that, Mr. Administrator, I wanted to ask you, What are you anticipating in the way of an impact on the Shuttle workforce?

Mr. O'KEEFE. We are looking to mitigate that as much as possible right now. And, indeed, folks are very busy in preparation in working through the issues on return to flight. If anything, I think we are going to be short of folks that we may need, because, again the nature of the recommendations that Admiral Gehman and the Board have released thus far, as well as those yet to come, will require a diligent, extremely vigorous implementation of that effort, which will require everybody in the space flight community turning to very, very hard.

Senator NELSON. By the way, Admiral, on the previous answer, why did we not discover on flight-day two that piece of debris trailing?

Admiral GEHMAN. Well, Senator——

Senator NELSON. Why was it only after the accident?

Admiral GEHMAN. Right. Senator, the United States does not currently track the Shuttle. The United States Air Force Space Command and the U.S. Strategic Command keep track of everything that is in space. They keep track of all of our satellites, including the Shuttle when it is on orbit, for the purpose of making sure they do not run into each other. But we do not track it in the

sense—like a fire-controlled guidance system or anything like that, that watches it.

After this accident, we asked the U.S. Strategic Command and the Air Force Space Command to go back over all their millions and millions of records and pull out all of their observations of the Shuttle to see whether or not any damage could be detected. They could not detect any damage, but they found 3100 observations of the Shuttle, due course, and they discovered, in their reconstruction, "Oh, look at this. Here is something that is orbiting alongside the Shuttle," which was reported to us six days after the accident.

Senator NELSON. Thank you for clarifying that.

Mr. O'Keefe, there is always this gut-wrenching question about whether the crew should have been told. What was the crew told about the strike by the foam and the likelihood of the damage?

Mr. O'KEEFE. To my knowledge—again, I will clarify this for the record if it needs further—they were not advised of that and were not advised of any significant damage, because, again, it was inside what was deemed, on every previous flight, every time that it occurred, within the realm of acceptable and not a safety-of-flight consideration. So, therefore, it was not raised with them specifically.

Senator NELSON. And——

Mr. O'KEEFE. Lots of other things were. Many other issues were raised with the crew regularly. But this did not rise to that level. That was a judgment call and one that was determined not to be a safety-of-flight consideration.

Senator NELSON. And, Admiral, as you make your recommendations, I would respectfully suggest that the old-timers would say that they would definitely want the crew involved.

Admiral GEHMAN. I think that if you will let us respond for the record, Senator, I think that we can shed more light on that subject. I think there is—I am not completely conversant with every detail, but the crew was advised at some time, and I do not know exactly when and what day it was or whether they were consulted or not. But let us get that for the record for you. There are some facts there.

Mr. O'KEEFE. On that point, Admiral, and exactly right, I guess the question, as I interpreted it, Senator—I apologize—was, "Were they specifically consulted and advised about it?" They received the daily flight reports from the Mission Management Team, and on those reports was the noted incident of strike and a resolution of the question, I believe, on day 12, in which, unambiguously, it says, "We've analyzed this, examined the issues, and determined it is not a safety-of-flight consideration." So it was treated as another data point. It was not something that was raised specifically.

So as you are well aware, the process during the course of on-orbit is you receive lots of data, lots of information, lots of reporting back and forth with mission control, and it comes in many forms, some by voice, some by the notice and requirements. But in this particular case, it was noted on the Mission Management Team reports, and that will be provided for the record, as I think it was on February 12th, at that hearing. But there was not a specific dialogue that I am aware of with the commander or the payload specialists—I am sorry—the mission specialists aboard that were spe-

cifically engaged in the activity. I do not believe that was the case, but I will provide that for the record, as well.

[The information referred to follows:]

On January 23, 2003, Steven Stich, a NASA Space Shuttle Flight Director who was working the Orbit 1 (first) shift in the Mission Control Center during the STS–107 mission, sent an e-mail to *Columbia* Commander Rick Husband, informing Col. Husband that NASA had observed some debris striking the orbiter during launch.

In this e-mail, Mr. Stich indicated that initial engineering analysis suggested that the debris did not pose a safety of flight issue to *Columbia*. Col. Husband replied to the e-mail, acknowledging its receipt and clearly indicating his understanding of the notification provided. A few hours later, Mr. Jeff Hanley, another Orbit 1 Mission Control member, transmitted a second e-mail to Col. Husband containing video of the launch and showing what appeared to be a piece of foam from the External Tank striking *Columbia*. No other communication in any form occurred between NASA and the crew concerning this matter.

The foregoing e-mail exchange used the "personal" e-mail channel, and followed receipt of several media inquiries concerning the foam debris visible during ascent. The Johnson Space Center newsroom believed the information might prove useful if questions were posed about it during a scheduled series of in-flight interviews on January 25. While the personal e-mail protocol was not created to provide mission-related information to orbiter crews, such use is not unusual or unprecedented. Although anticipated operational, media, and other issues are normally provided to the crew as part of a standard daily "package," NASA has reviewed each of these packages, and has confirmed this exchange as the sole source of information on the debris strike provided *Columbia*.

The STS–107 Mission Management Team (MMT) finished its evaluation of the debris strike on January 27, four days after the Stich-Husband e-mail exchange. Based on the findings of the debris assessment team, the MMT concluded that the debris impact did not pose a safety of flight issue; consequently, no additional information was provided to the *Columbia* crew.

Copies of the MMT minutes, this e-mail exchange, and the daily "packages" will be available on the NASA web site at: *http./www.nasa.gov/columbia/foia/index.html*

Senator NELSON. Well, I know that to cut the crew out, you are eliminating a great resource, and I know that there have been many occurrences where emergencies have arisen in the past that the crew responded immediately and had the problem fixed before mission control even knew about it. So you all will deliberate that in due time.

Well, let me just wrap up here for the Chairman, and you can provide these for the record.

What I want to do is what all of us want to do. I want us to get the problem fixed and get flying and get back and utilize these wonderful assets that we have out there, including the Space Station. But we are going to have to attend to safety in a way that we never have. And, of course, you have heard me rail from this podium in the past about, over the past decade, of the safety upgrades not being done on the Space Shuttle, and delayed.

So if you, Mr. Administrator, will provide for the record, How does NASA determine what Shuttle upgrades are required, and how these upgrades will be selected and prioritized? And does NASA have a 2020 plan to show when the Shuttle-upgrade requirements will be completed? And then if you will round that out as we are grappling to get the technologies for a follow-on vehicle, why have we seen so many missteps in the development of a second-generation technology in NASA's program?

Any comment now? And then, if you would, supply the rest of it for the record.

Mr. O'KEEFE. Yes, sir. I will be delighted to provide all that for the record.

[The information referred to follows:]

General Michael Kostelnik, Deputy Associate Administrator for the International Space Station and Space Shuttle Programs, initiated a new Space Shuttle Service Life Extension Program (SLEP) during the past year, which is responsible for providing a coordinated review of the Space Shuttle upgrades by the entire space flight community. During the annual SLEP Conference, the Chairmen of the seven SLEP panels—Safety, Sustainability, Infrastructure, Resources, Industry, Performance, and Operations—present the prioritized list of upgrades their panels support for the coming year. The Integration Panel prioritizes these seven sets of upgrades into a single set of requirements, which is presented to the Space Flight Leadership Council. The Space Flight Leadership Council approves the final upgrades requirements for inclusion as part of NASA's annual budget cycle. As long as the Space Shuttle is required to be available for flight, the SLEP process will be conducted to ensure that the Space Shuttle is maintained at the proper level for safe human space flight.

Mr. O'KEEFE. We are moving ahead aggressively on the orbital space plan to guarantee a crew-transfer vehicle capacity between here and the International Space Station. That is its mission, that is its objective. To use, then, the Shuttle for the purpose of the heavy-lift cargo capacities, as required. That is a mid-term kind of a requirement.

We are also developing the next-generation launch technologies which will ultimately provide for a space-exploration vehicle. Whether it is a replacement for Shuttle or not is something that, really, we ought to think about long and hard, because it is only capable of orbit within low-earth orbit, it has minimal maneuverability, it has no power-generation source of its own, all of which are things we need to correct, from a technology standpoint, to look at anything beyond low-earth orbit. I think you will see emerge from this process an answer on that front for the longer term, "What replaces this capability for more expansive space-exploration objectives," in very short order.

Senator NELSON. Gentlemen, thank you very much. The meeting is adjourned.

[Whereupon, at 11:50 a.m., the hearing was adjourned.]

# A P P E N D I X

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

*Question 1.* In the recently submitted NASA *FY 2003* Operating Plan, it was stated in the Congressional Increases section that $900,000 had been provided for the "Computing, Information, and Communication Technology Program only for Mobile, Wireless, and Broadband Internet Capability." It was indicated in the plan that this earmark had been inadvertently dropped as an earmark from the final Conference compilation. Can you explain how this process of adding "inadvertent" earmarks works within NASA?

Answer. The Congressional increase for the item in question was included as part of total funding provided for Aerospace Technology programs in House Report 107–740, accompanying H.R. 5604, the FY 2003 VA–HUD-Independent Agencies Appropriations Bill. Conference action yielded a total for Aerospace Technology that was $900,000 greater than all items listed in the Report. Committee staff subsequently notified NASA that this item had been inadvertently omitted from the Conference Report, and requested that NASA include it in the Operating Plan as a technical correction.

*Question 2.* Based upon commercially available satellite imaging, can you comment on the utility of having satellite images of the *Columbia's* left wing on-orbit?

Answer. NASA has significantly enhanced procedures in place to maximize available national assets to assess Shuttle orbiters during human space flight missions. The memorandum of agreement between NASA and NIMA was finalized on July 11, 2003.

*Question 3.* What lessons has NASA learned from its analysis of the *Columbia* tragedy? What have you done to ensure that these "lessons learned" are fully integrated into NASA's management and operations? Is there a definitive "lessons learned" program at NASA to minimize the repetition of past mistakes?

Answer. On February 1, 2003, NASA pledged to the *Columbia* families that we would find the problems, fix them and return to the exploration objectives to which they dedicated their lives. NASA has just received the Columbia Accident Investigation Board (CAIB) report, which fulfills the first of NASA's commitments to the families. To fulfill the second commitment—fixing the problems—the first important step is that NASA has accepted the findings and recommendations of the CAIB report and will comply with them. The CAIB report represents a valuable blueprint and roadmap to achieving the second commitment, and the Board provided NASA a head start by releasing information throughout their deliberations. As of this time, NASA has developed a preliminary Implementation Plan for the recommendations of the CAIB, and will update it now to include all the findings and recommendations. The next step involves wise choices by NASA to select the options necessary to comply with the recommendations. In addition, all of the "lessons learned" will be documented in the NASA Lessons Learned Information System including information and recommendations provided by the CAIB.

*Question 4.* Questions have been raised by NASA's impact analysis performed by Boeing of the foam strike on the left wing of the *Columbia.* In response to post hearing questions from the Committee's earlier hearing on the *Columbia* accident, NASA stated the results of scenarios 5 and 6 from the impact analysis were "discussed". Is this an acceptable practice of documenting results at NASA?

Answer. Results of the analysis were presented (discussed) during a Mission Management Team (MMT) meeting during the STS–107 flight. This MMT process is being strengthened to provide rigor and a requirement for documented presentations.

*Question 5.* What role did the NASA Safety Office play in the assessment of the impact analysis?

Answer. The safety community was actively engaged in the review and assessment of the impact analysis that was prepared and presented by Boeing. A safety

representative (from the JSC safety organization) was present at all the meetings during which this topic was discussed, including the Mission Management Team briefings. The safety community agreed with the conclusion that a safe return of the vehicle was likely, provided that the suspected damage was bounded within the limits of the damage assessment estimates and the analytical capability. The safety community, based on input from the safety representative on the team through status reporting up to the Associate Administrator, Office of Safety and Mission Assurance, was aware of the findings and recommendations of the analysis and concurred with the Shuttle program's assessment that there was no significant re-entry risk due to any anticipated tile damage. Further, a safety representative was present at all of the Shuttle program manager's weekly status teleconferences, where the topic was openly discussed among all the team members.

*Question 6.* The Columbia Accident Investigation Board has already made two recommendations. The first one was that NASA should develop and implement a comprehensive inspection plan, using advanced non-destructive inspection technology, to determine the structural integrity of all Reinforced Carbon-Carbon (RCC) system components. The second recommendation was that NASA should modify its Memorandum of Agreement with the National Imagery and Mapping Agency (NIMA) to make on-orbit imaging for each Shuttle flight a standard requirement. What steps have you taken to implement these recommendations, and how much will they cost?

Answer. NASA is in the process of developing the comprehensive plan for inspecting all RCC components. A technical interchange between NASA and industry representatives was recently held to assess available state-of-the-art methods of non-destructive inspection. Additional non-destructive inspection methods, such as thermography and shearography, are being evaluated to determine their effectiveness in determining potential flaws in various materials used in the Shuttle program.

Additionally, NASA and the NIMA have finalized an updated agreement for support of Space Shuttle missions.

*Question 7.* What type of inspections was NASA doing to the RCC components on the leading edges of the Shuttle wings prior to the *Columbia* accident?

Answer. As specified in the Orbiter maintenance document, the following inspection were conducted on the wing leading edges of each Orbiter:

- Surface tactile inspection—every flight
- Visual surface inspection—every flight
- Pre/post-flight lower access panel micro inspections—every flight
- RCC pinhole inspection—every Orbiter maintenance and major modification period
- Detailed breakdown inspection including eddy current and ultrasound—every Orbiter maintenance and major modification period

*Question 8.* According to press reports, NASA has begun a widespread review of critical design and safety features and management practices to prepare for returning the Space Shuttle to flight. NASA officials are reported to believe that it could take 18 to 24 months before the Shuttle will fly again. Could you please describe what NASA is reviewing, and NASA's "return to flight" strategy?

Answer. Return to Flight actions will consider, but not be limited to:

- Review the adequacy and robustness of key Space Shuttle hardware systems.
- Review the Certificate of Flight Readiness and MMT process
- Quantify entry risk
- Validate that controls are appropriate and implemented properly for accepted risks
- Review Failure Modes and Effects Analyses, Critical Items Lists, Waivers, etc.
- Review the identification and resolution of the in-flight anomaly review process.
- Redesign of External Tank Bi-Pod thermal protection system to eliminate foam.
- Improved vehicle inspection techniques and methods during launch, ascent and on-orbit operations
- Develop on-orbit thermal protection system repair techniques.

Reaching specific milestones will drive NASA's Return to Flight effort, not specific calendar dates. NASA is working toward a target launch date for planning purposes, to keep Space Shuttle and Return to Flight processing moving forward, but the Agency is not locked into any particular date. NASA will launch STS–114 when the

Agency determines that the Shuttle is "fit to fly" and when we have safely achieved specific milestones throughout the Return to Flight effort.

*Question 9.* The halt in Space Shuttle operations will delay the construction of the International Space Station—a program that is already well known for schedule delays and cost overruns. What effect will the *Columbia* accident have on schedule and costs of construction of the Space Station?

Answer. NASA has maintained the original delivery schedules for all items of U.S.-provided Space Station flight hardware and is continuing with the integration and test of all ISS launch packages as planned. Additionally, the European-provided, U.S.-owned Node 2 was delivered to NASA Kennedy Space Center in June 2003, completing the delivery of all flight elements needed to complete the U.S. Core configuration. However, delays to the ISS assembly sequence resulting from the *Columbia* accident will require NASA to retain critical contractor expertise longer than anticipated. NASA has just received the report of the CAIB. We will not know the extent of overall delays or costs until we have received and assessed the final recommendations of the CAIB and progressed further into our return to flight planning.

*Question 10.* Last year NASA appointed a Mishap Investigation Board to examine the loss of the CONTOUR mission, a satellite that broke apart last August. Are the *Columbia* and CONTOUR accidents being treated as isolated events or in context of NASA's long term plans?

Answer. The CONTOUR and *Columbia* accidents are both being addressed in terms of NASA's long-term plans. While these accidents involved very different kinds of spacecraft, there are nonetheless some important common elements in both mishaps with regard to NASA's approach to engineering rigor, processes, and instincts. These common elements are among those addressed in ongoing improvements to NASA's engineering culture, in part by the establishment of the NASA Engineering and Safety

*Question 11.* Could you please expand upon the purpose of General Stafford's independent assessment team and the role that it will play in NASA's implementation on the *Columbia* Accident Investigation Board's recommendations?

Answer. The Return to Flight Task Group, led by Gen. Tom Stafford, has been tasked to perform an independent assessment of NASA's actions to implement the recommendations of the CAIB, as they relate to the safety and operational readiness. 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 their intent.

*Question 12.* Can you update us on your consideration of crew escape mechanisms on the Shuttle orbiters?

Answer. Crew survivability has been studied continuously since the *Challenger* accident. Through the Shuttle Life Extension Program (SLEP), additional studies are planned to further refine a number of crew escape concepts that were developed in a 1999 study conducted by the Orbiter Project together with United Space Alliance and Boeing Company.

*Question 13.* You testified during the hearing that you were concerned by the "normalization of deviation" at NASA, especially the toleration of foam insulation falling from the External Tank, because it happened so many times it was considered an acceptable condition. The recent return of Expedition 6 by Soyuz capsule was also considered an "outside-the-norm" landing pattern, but NASA has claimed that it was not a "safety-of-flight" issue, because similar landings had occurred before. Are you concerned that NASA's response to the Soyuz landing is yet another case of "normalization of deviation?" What do you intend to do to ensure that the cause of this "outside-the-norm" landing is found and fixed, so that it doesn't happen again?

Answer. The ballistic mode of re-entry for the Soyuz TMA–1 (ISS Flight 5S) descent module was one of four pre-programmed modes of re-entry. Soyuz crews are trained for all four modes. The ballistic re-entry was conducted safely and as designed and the Soyuz TMA–1 (ISS Flight 5S) landed in the predicted ballistic descent landing zone. The crew was never in danger.

Experts from Russia and the United States are making every effort to fully understand and resolve the factors that contributed to the Soyuz TMA–1 (ISS Flight 5S) spacecraft's return to Earth in the backup ballistic mode. The Russian Aviation and Space Agency (Rosaviakosmos) established a technical investigative Board, which it calls a "Commission," led by RSC Energia the responsible organization for Soyuz manufacturing, to determine the cause of this mode of re-entry and provide specific recommendations. The Commission determined that the Soyuz automatically

switched to the ballistic mode shortly before re-entry when the on-board computers received an indication of a failure in the capsule's electronic attitude control system.

The NASA Advisory Council Task Force on International Space Station Operational Readiness (the Stafford Task Force) will work with its counterpart Russian organization, the Rosaviakosmos Advisory Expert Council (together referred to together as the Stafford-Anfimov Joint Commission), to conduct an assessment of the Commission's investigation of the Soyuz TMA–1 (ISS Flight 5S) re-entry. This assessment occurred during the week of July 21 in Moscow. The Deputy Associate Administrator of NASA's Office of Safety and Mission Assurance is an ex-officio member of the Stafford Task Force and will be integrally involved in the Joint Commission's review of the Commission's investigation.

NASA, which has been regularly briefed by the Commission throughout its investigation, will review the Commission's investigation, and the assessment of that investigation, by the Stafford-Anfimov Joint Commission. NASA will continue to work with our Russian colleagues to ensure that all necessary follow-up actions are implemented.

*Question 14.* I understand that the tiles are so sensitive that the Shuttle will not launch in the rain, and touching them can cause damage. If this is the case, why, when there was an image of debris hitting the tiles, did not this result in the immediate classification of this event as a serious emergency that threatened the loss of crew and/or orbiter?

Answer. Given the information available at the time that the foam hit the wing of *Columbia*, it was presumed that the impact was to the tile-covered underside of the wing and not the leading edge. A tile assessment and analysis concluded that the impact to tile was not a safety of flight issue. If it had been known that the impact was to the wing leading edge, a different analysis would have been conducted.

*Question 15.* NASA has stated that safety is a top priority for the agency. What role did NASA's safety office play in the decision concerning *Columbia's* re-entry?

Answer. The safety community was actively engaged in the review and assessment of the impact analysis that was prepared and presented by Boeing. The Shuttle's Mission Management Team includes a safety representative. Safety personnel agreed with the conclusion that a safe return of the vehicle was likely, provided the suspected damage was bounded within the limits of the damage assessment estimates and the analytical capability. The safety community, based on input from the safety representative on the team through status reporting up to the Associate Administrator, Office of Safety and Mission Assurance, was aware of the findings and recommendations from the analysis and concurred with the Shuttle program's assessment that there was no significant re-entry risk due to any anticipated tile damage.

*Question 16.* Recently, the Soyuz, which is the only vehicle currently being used to reach the International Space Station, missed its landing target by 300 miles, and came in at the wrong angle, subjecting its 3-man crew to high gravitational forces. What has NASA's Safety office done to address concerns about Soyuz's safety and reliability?

Answer. Russia's RSC Energia, which is responsible for Soyuz manufacturing, established a technical review Board to conduct an investigation into the possible causes of the Soyuz TMA–1 spacecraft's return to Earth in the "ballistic mode" of re-entry. The Board determined that the ballistic descent mode likely occurred due to the failure of one of the descent control system instruments. The Board was then tasked with detecting the failure location, specifying its origin, and generating specific recommendations to prevent similar situations from occurring during subsequent flights of the Soyuz TMA spacecraft.

It should be noted that the ballistic mode of re-entry for the Soyuz TMA–1 descent module was one of four possible programmed modes for re-entry. Soyuz crews are trained for all four-re-entry modes. The Soyuz TMA–1 landed in the predicted ballistic descent-landing zone.

The NASA Advisory Council Task Force on International Space Station Operational Readiness (the Stafford Task Force) will work with its counterpart Russian organization, the Russian Aviation and Space Agency (Rosaviakosmos) Advisory Expert Council (referred to together as the Stafford-Anfimov Joint Commission), to conduct an assessment of the Energia Board's investigation of the Soyuz TMA–1 re-entry. This assessment occurred during the week of July 21, 2003 in Moscow.

NASA will review the Energia Board's investigation and the assessment of that investigation by the Stafford-Anfimov Joint Commission, and will continue to work with our Russian colleagues to ensure that all necessary follow-up actions are implemented.

*Question 17.* Given the history of tile damage to the Shuttle orbiters during a mission, do you have any thoughts as to whether or not on-orbit contingency plans should address this problem?

Answer. NASA is currently assessing various new technologies that could provide methods to inspect and repair damage to the Orbiter's thermal protection system during flight. Previously, there were no methods available that did not subject the crew or vehicle to additional risk.

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RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. BILL NELSON TO HON. SEAN O'KEEFE

*Question 1.* How does NASA determine what Shuttle upgrades are required and how these upgrades will be selected and prioritized?

Answer. The new Space Shuttle Service Life Extension Program (SLEP) addresses the critical investments that will ensure the Space Shuttle can safely and effectively meet the requirements of the new Integrated Space Transportation Plan. The Deputy Associate Administrator for International Space Station and Space Shuttle Programs has created a process—the SLEP Summit—that will meet annually to identify and frame the immediate and long-range investment direction and strategy for SLEP.

In preparation for the SLEP summit, eight panels were identified to examine and prioritize potential investments. The panels focused on Space Shuttle safety, sustainability, infrastructure, resources, operations, and performance issues. In addition, an industry panel was chartered to provide a unique industry perspective. With the exception of the industry panel, each panel was lead by a senior NASA manager and populated with a diverse membership across each space flight center and relevant NASA Headquarters functional offices and Enterprises. The panels were tasked with assessing the potential costs, risks, and benefits of additional investments for their respective areas.

The first SLEP Summit was held on March 19–20, 2003 in Michoud, LA. The Panels briefed those in attendance and the Space Flight Leadership Council (SFLC) on their findings and recommendations for the strategic investments needed to maintain and improve the long-term operational capability of the Space Shuttle. On May 7, 2003, the SFLC selected its top priorities for investment from among the panels' recommendations. Additionally, recommendations from the Columbia Accident Investigation Board requiring long-term investment are likely to be incorporated into the SLEP process.

A SLEP Summit will be held annually to re-evaluate and update Shuttle priorities and investment strategies.

*Question 2.* Does NASA have a 2020 plan to show when the Shuttle upgrade requirements will be completed?

Answer. The 2020 plan was an internal study that provided a foundation for identifying the resources required to maintain the safety and sustain the viability of the Space Shuttle program through 2020. The Space Shuttle Service Life Extension Program (SLEP) is our current process. SLEP will prioritize and implement immediate and long-range investment direction and strategy for the Space Shuttle. This includes many of the recommendations that were derived from the 2020 study. Since a SLEP Summit will be held annually to re-evaluate and update Shuttle priorities and investment strategies, there is no detailed long-range plan roadmap that describes exactly what upgrades will be completed when.

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

*Question 1.* Another issue that has been raised is about privileged information that the Board has gained from confidential interviews with witnesses. Could you please explain the importance of this privileged information to your investigation, and what will become of this "privileged" testimony after the Board's work is done?

Answer. The Columbia Accident Investigation Board (CAIB) conducted essentially two investigations in one. The first investigation was the accident investigation, that is, an investigation to determine what happened to the *Columbia*. This accident investigation was conducted with full disclosure of all processes and evidence obtained in support of the Board's findings and recommendations. The second investigation could be described more accurately as a safety investigation. It used procedures long established as effective by various government agencies, including allowing individuals to express frank and honest views and opinions in a manner that

protects them from any threat, real or perceived, of retaliation from their organization. The statements of these individuals provide a very important view of organizational practices that relate to safety. Experience has shown that investigations frequently cannot obtain candid, truthful, or possibly incriminating information any other way. Therefore, being able to grant witnesses confidentiality is very important to the Board. The ultimate disposition of these protected statements has not yet been determined. If they are archived by the National Archives along with the rest of the Board's documents, every effort will be made to ensure that the Congress-CAIB agreement, regarding access and disclosure, will remain in effect.

*Question 2.* In testimony before the Science, Technology, and Space Subcommittee, Dr. Alex Roland, a former NASA historian, testified that NASA originally planned for the fleet of Space Shuttles to be replaced every five years. Many observers have warned that the Space Shuttle is being used past its expected lifetime, and that it is becoming obsolete. There have even been reports that NASA engineers have to use the Internet site, E-Bay, to find sources for parts. Based on your investigation, do you believe that the Space Shuttle has become "worn out" and should be replaced?

Answer. The referenced incident involving an E-Bay parts search involved an obsolete circuit card for a personal computer, part of a shop test equipment set at the NASA Shuttle Logistics Depot (NSLD); it was *not* flight hardware, which requires full certification in all instances. NSLD personnel work very hard to either repair parts or have spares available. From May 2, thru Apr 3, 18,213 parts were delivered from stock with no orbiter cannibalizations, a testament to effective repair and stocking efforts. For flight hardware as well as ground systems equipment, one of the significant challenges to NSLD has been what is referred to as "Diminishing Manufacturing Sources," or DMS. The availability of spare parts is an ongoing challenge for all systems, not just the Shuttle, but has little to do with the Shuttles being "worn out." The Shuttle mission life capability is continually updated by NASA, which has concluded that 100 missions are achievable.

*Question 3.* One area that the Board said it would investigate concerns NASA's use of contractors. Specifically, the Board has indicated that it will examine NASA's inspection and oversight of contracts, and whether NASA is making high enough demands from private companies in its contracts. Could you please discuss the work that the Board has done in this area?

Answer. The CAIB has examined the relationship between NASA and its contractors at various levels, starting at the top (Space Flight Operations Contract) and including actual performance at the tactical level (e.g. Government Mandatory Inspection Points/GMIPs, surveillance, and Foreign Object Debris/FOD prevention). The final report will include specific recommendations on modifying and improving the current contract and government-contractor relationships at these various levels.

The trend in government over the last 15 years has been toward decreased government execution, with contractors performing more execution and the government providing oversight.

NASA has also followed this trend, but as headcount NASA has been reduced, there has also been a shift from NASA's *intensive monitoring* to NASA's *sampling and auditing*, with an increased dependence on partnering, moving NASA further from actual technical performance and into performance monitoring. Prime contactor cuts have, in turn, resulted in "self oversight" of critical suppliers. Emphasis on partnering has blurred lines of responsibility and accountability between NASA and its contractors.

Additionally, performance-based contracting has proven difficult in terms of emphasizing and measuring the right things with the appropriate benchmarks, such as outcomes, milestones, result, launches and compliance at lower/intermediate levels. In general, award fee scores are high, but it is important to understand what is being measured, as well as what impact the scoring system itself has on performance.

*Question 4.* At the Board's March 6 hearing, Henry MacDonald, a former Director of the NASA Ames Research Center, stated that the NASA's recordkeeping was poor and that its records cannot be searched by modern tools like Web browsers. He said that there was no easy way for managers to search NASA records for the four previous occasions where pieces of foam insulation fell off of the external tank. Could you please comment on this testimony, and the role that this database and other inadequately designed management tools may have played in NASA's decisions regarding the *Columbia*?

Answer. NASA's system for tracking problems and corrective actions across the Space Shuttle Program (SSP) is cumbersome to use, not well-integrated across various centers and program elements, and difficult to search or use for analytical pur-

poses. That said, it is difficult to show that these shortcomings played a direct role in management decisions relating to *Columbia*, or otherwise contributed to the accident.

The Problem Reporting and Corrective Action (PRACA) System is the SSP's system for reporting problems and tracking corrective actions on Space Shuttle hardware and software. Throughout the investigation, the CAIB heard repeatedly from NASA employees and contractors about difficulties with this system, and experienced many of these same problems during limited first-hand attempts to use it.

In an effort to integrate PRACA databases across different centers, NASA initiated the Web Program Compliance and Status System (WEBCASS). While it provides the user access to consolidated information with some higher-level search capability, it is still reportedly difficult to use.

Database shortcomings cannot be directly implicated in decisions relating to foam. The history of falling foam was well known, and most managers could recall from memory the major incidents, particularly those involving bipod ramp foam. The fact that there was a well-known history, without catastrophic consequences, is reflected in repeated statements that foam has never been a safety of flight issue.

*Question 5.* You mentioned during the hearing the extensive use of accelerometers on the Shuttle's exterior. What is the extent of capability in temperature sensors on the exterior? Are they sensitive enough to detect any abnormality due to damage tiles?

Answer. There were 94 temperature sensors on *Columbia*, 50 of which were surface temperature sensors. Forty-one were mounted in tiles, eight were structure temperature sensors, and one was on an insulation blanket. All of these surface temperature measurements were recorded on the Modular Auxiliary Data System, which was recovered in southeast Texas.

Any disturbance in surface smoothness will manifest itself as a downstream flow field disturbance. Thus, if the temperature sensor is close enough to the damage and the damage is large enough, it is possible that the sensor would detect a disturbance. However, the tiles are very good insulators, so small damage in a tile that also has a temperature sensor embedded in it may not sense the damage.

Observers have noted the many similarities and differences between the Rogers Commission and the Columbia Accident Investigation Board.

*Question 6.* What lessons did you learn from the Rogers Commission and apply to your investigation into the *Columbia* tragedy?

Answer. The Columbia Accident Investigation Board benefited significantly from the Rogers Commission and even includes members who participated in the *Challenger* accident investigation. All CAIB members read the Rogers Report and spoke to people with knowledge regarding how the *Challenger* investigation was organized. The lessons learned are many, including:

- Don't assume anything
- Don't fall in love with the first plausible cause scenario
- Break up into independent work groups
- Independently verify certain matters
- Crosscheck testimony
- Public hearings are valuable

*Question 6a.* Based on your investigation, do you believe that NASA is continuing to operate under the "lessons learned" from the *Challenger* accident, or have these lessons been forgotten?

Answer. This issue is currently under review by the CAIB. It would be premature to express what the Board might finally decide, however, this is certainly a matter at which the Board is taking under consideration.

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