INVESTIGATION OF THE CHALLENGER ACCIDENT

(Volume 1)

TUESDAY, JUNE 10, 1986

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The committee met, pursuant to notice, at 9:38 a.m., in room 2318, Rayburn House Office Building, Hon. Robert A. Roe (acting chairman of the committee) presiding.

Mr. ROE [acting chairman]. Good morning, ladies and gentlemen. The House Science and Technology Committee will now convene.

And, without objection, television broadcasts, radio broadcasts, still photography, or other means of coverage will be permitted during the full committee hearings this week on the Rogers Commission report.

Today the House Science and Technology Committee begins an intensive series of congressional hearings into the causes and the ramifications of a great national tragedy—the explosion of the space shuttle *Challenger* and the loss of seven true American heroes.

These hearings will take a three-pronged approach. First, we will look at the technology and the hardware that caused the accident. Second, we will closely examine the management problems and decisionmaking problems within NASA. And the last focus of our hearings, and perhaps the most important phase, will deal with the future of our Nation's space program, and the question we must answer is "Where do we go from here?"

The Presidential Commission on the Space Shuttle Accident has made its report to the American people. The distinguished Chairman of the Commission, the Honorable William P. Rogers, whom we will hear from shortly, has done an outstanding job in presenting to the Nation a remarkable document which fully, truly details the entire story of the failures in technology and human error that ultimately led to the shuttle disaster.

I would like to take this opportunity to congratulate Chairman Rogers and the other members of his Commission for a job well done.

It is not the intention of this committee to simply rehash what the Rogers Commission has so ably accomplished. We must instead utilize the Rogers report as the basis for a new start in America's space efforts.

I would like to quote from the Commission's concluding thought, and I quote:

> The commission urges that NASA continue to receive the support of the administration and the nation. The agency constitutes a national resource that plays a critical role in space exploration and development. * * * The findings and recommendations presented in this report are intended to contribute to the future NASA successes that the Nation both expects and requires as the 21st century approaches.

It is very clear that because of its great success story Congress has been too shy in finding fault with NASA. As the result of the *Challenger* accident, Congress and NASA must begin a new era, one in which Congress must apply the same strong oversight to NASA that it does to any other Government agency.

There can be no doubt that we are at a critical turning point in our space program. The *Challenger* accident combined with the recent failures of our Titan and Delta rocket systems has raised deep concern and some doubts as to what the future holds for us.

The central theme, again, of these hearings must be, Where do we go from here? The Rogers Commission has answered the basic question of what happened to the *Challenger.* But it also leaves many other cogent questions unanswered: Do we need a new fourth orbiter or a space station? Should future space efforts be centered on unmanned rather than manned flights? What needs to be done to get us back on track?

I think it is basically clear that when we discuss where this country is going in space, we are talking about the very future of our potential growth in science, technology, national security, and communications. These and other key areas will be affected by how we respond to these recent failures.

It is the intent of these hearings to uncover some of the answers to lead us back to our role of supremacy in space and the advancements of high technology associated with that leadership to the future benefit of all mankind.

The Chair now recognizes the distinguished chairman of the Science and Technology Committee, the Honorable Don Fuqua from the State of Florida.

Mr. FUQUA. Thank you, Mr. Roe, and for your remarks.

And I want to join you in praising the work of the Commission. I believe that the investigation will serve as a model for its thorough and comprehensive and deliberate approach to a most difficult undertaking.

And to the chairman, Secretary Rogers, and Vice Chairman Armstrong, both of you can take great pride in your leadership and that of the Commission in producing an inclusive report. The Nation is still suffering from the effects of a very terrible tragedy, but I believe that your report will stand the test of time.

As a member of this committee, I have been involved in the development of NASA programs for the past 24 years. And, consequently, it's especially painful for me to participate in a hearing such as this today. I have witnessed the joys and the triumphs of all the manned spaceflight programs and suffered through the tragedy of the Apollo 204 fire and now the space shuttle mission designated as 51–L. To say the least, it has been a roller coaster of emotions. But through the analysis of what went wrong in the

Apollo fire, we found the confidence and fortitude to go forward with that historymaking program.

We're now again facing the test of what direction this Nation takes in its future manned spaceflight programs. I am confident that the Congress, with the support of the American people, will make the right decisions.

The Commission report is bluntly critical. It is an indictment of both management and technical arrogance brought about by the mindset caused by a period of spectacular successes. If we fail to remind ourselves that space is a very hostile environment, to be conquered only by constant vigilance and continuing attention to detail, we will again someday have another catastrophic failure. We in Congress, as well as NASA and the aerospace industry, must never again be lulled into a sense of overconfidence that could contribute to such a tragedy. While history does not repeat itself, unfortunately people can repeat history.

And so I suggest today a new beginning, a new era in the history of NASA, one that does not forget the past but profits from it to build on a stronger space program. After the Apollo fire, we accepted the fact that we had erred and we conquered those problems and made NASA a much stronger institution.

We must and will make the changes necessary to come out of this tragedy with a better and stronger program. And to do otherwise is to shirk our responsibility and commitment to those seven brave individuals who gave their lives in pursuit of our national goal.

Thank you, Mr. Chairman.

Mr. Roe. I thank the distinguished chairman.

The Chair now recognizes the distinguished ranking minority member, the Honorable Manuel Lujan from New Mexico for an opening statement.

Mr. Lujan. Thank you, Mr. Chairman.

Chairman Fuqua and Chairman Roe, I welcome this report, and I congratulate Chairman Rogers and Vice Chairman Armstrong on the way in which they conducted their investigation and set forth their findings. They've been tough and fair at a time when both were called for.

I would also like to compliment each of the other commissioners and staff members on their individual contributions and dedication to this effort. They have fulfilled the mandate given them by President Reagan with great dedication in a highly compressed time period while under enormous pressure. All have done an admirable job in accomplishing a very difficult task.

On the surface the Commission's conclusions appear devastating to those who thought that our space agency could do no wrong. While the Commission's words are strong and its criticism of NASA blunt, I believe its findings will ultimately be constructive in nature. Because the scope of the Commission's mandate was limited to investigating the cause of the accident and related safety issues, it necessarily left many of the basic policy questions unanswered.

It is now this committee's responsibility to address those broader issues. In the weeks and months ahead we will call on NASA and its contractors to fully respond to our questions. We must continue to investigate this accident and the full range of operational, management, and policy issues it raises.

Our work will not be complete until we're fully satisfied with the answers we get. We must continue to probe until we're sure that the chain of events which led to this tragedy will never again be repeated. NASA, its contractors, and outside experts will all have an opportunity to add their views.

As a committee, we must conduct our investigation with an open mind. Our hearings must be honest, frank, and fair, but we will draw our own independent conclusions. Should we find evidence of mismanagement, poor judgment, or even negligence, we must take appropriate action.

In the future we must never allow the previous successes of our space program to breed overconfidence. As a committee, we may have been too trusting in the past when NASA gave us glowing, optimistic reports about our space program. Hindsight suggests that NASA's view of the space shuttle program was not realistic.

This Nation cannot abandon its space program. The *Challenger* accident and its aftermath mark a new beginning, not an end. In the past 4 months this Nation has lived through a very difficult time. The time has now come for all of us to put the national nightmare of *Challenger* behind us. Seven brave men and women who reached for the stars, in the words of the poem, "touched the face of God" deserve no less.

Thank you very much, Mr. Chairman.

Mr. Roe. I thank the gentleman from New Mexico.

In view of the limited amount of time, without objection, all remaining opening statements of the members will be included in the record at this point.

[The prepared opening statements by members of the committee follow:]

Statement of

Hon. Bill Nelson

June 10, 1986

Now that the Presidential Commission on the Space Shuttle Challenger Accident has completed its work, it is time for the Congress to begin its efforts to grasp the causes of the accident and to determine what hardware and management changes should be made in the program.

I believe that the Roger's Commission has done an excellent job and that their report provides us with a firm basis to begin our investigation into the matter.

In the 24 successful flights prior to the accident, the Space Shuttle demonstrated what a marvelous and invaluable tool it can be in helping this country develop and use space for the benefit of all mankind.

It is now clear, however, that engineering and management mistakes have been made in the Shuttle program. Our task, therefore, is to pinpoint where in the program these mistakes originated and then to work closely with NASA to ensure that all of these problems are fully corrected so that the Space Shuttle can return safely to flight operations and resume making its valuable contributions to the American space program.

OPENING STATEMENT

BY

HON. MANUEL LUJAN, JR. (R-N.M.)

RANKING REPUBLICAN MEMBER

COMMITTEE ON SCIENCE AND TECHNOLOGY
AT THE PRESENTATION OF THE
REPORT OF THE PRESIDENTIAL COMMISSION ON THE
CHALLENGER ACCIDENT

JUNE 10, 1986

CHAIRMAN FUQUA AND CHAIRMAN ROE, I WELCOME THIS REPORT. I CONGRATULATE CHAIRMAN ROGERS AND VICE CHAIRMAN ARMSTRONG ON THE WAY IN WHICH THEY HAVE CONDUCTED THEIR INVESTIGATION AND SET FORTH THEIR FINDINGS. THEY HAVE BEEN TOUGH AND FAIR AT A TIME WHEN BOTH WERE CALLED FOR. I WOULD ALSO LIKE TO COMPLIMENT EACH OF THE OTHER COMMISSIONERS AND STAFF MEMBERS ON THEIR INDIVIDUAL CONTRIBUTIONS AND DEDICATION TO THIS EFFORT. THEY HAVE FULFILLED THE MANDATE GIVEN THEM BY PRESIDENT REAGAN WITH GREAT DEDICATION IN A HIGHLY COMPRESSED TIME PERIOD WHILE UNDER ENORMOUS PRESSURE. ALL HAVE DONE AN ADMIRABLE JOB IN ACCOMPLISHING A VERY DIFFICULT TASK.

ON THE SURFACE, THE COMMISSION'S CONCLUSIONS APPEAR DEVASTATING TO THOSE WHO THOUGHT OUR SPACE AGENCY COULD DO NO WRONG. WHILE THE COMMISSION'S WORDS ARE STRONG AND ITS CRITICISM OF NASA IS BLUNT, I BELIEVE ITS FINDINGS WILL ULTIMATELY BE CONSTRUCTIVE IN NATURE. BECAUSE THE SCOPE OF THE COMMISSION'S MANDATE WAS LIMITED TO INVESTIGATING THE CAUSES OF THE ACCIDENT AND RELATED SAFETY ISSUES, IT NECESSARILY LEFT MANY BASIC POLICY QUESTIONS UNADDRESSED. IT IS NOW THIS COMMITTEE'S RESPONSIBILITY TO ADDRESS THOSE BROADER ISSUES.

IN THE WEEKS AND MONTHS AHEAD, WE WILL CALL ON NASA AND ITS CONTRACTORS TO FULLY RESPOND TO OUR QUESTIONS. WE MUST CONTINUE TO INVESTIGATE THIS ACCIDENT AND THE FULL RANGE OF OPERATIONAL, MANAGEMENT AND POLICY ISSUES IT RAISES. OUR WORK WILL NOT BE COMPLETED UNTIL WE ARE FULLY SATISFIED WITH THE ANSWERS WE GET. WE MUST CONTINUE TO PROBE UNTIL WE ARE SURE THAT THE CHAIN OF EVENTS WHICH LED TO THIS TRAGEDY WILL NEVER AGAIN BE REPEATED. NASA, ITS CONTRACTORS AND OUTSIDE EXPERTS WILL ALL HAVE AN OPPORTUNITY TO AIR THEIR VIEWS.

AS A COMMITTEE, WE MUST CONDUCT OUR INVESTIGATIONS WITH AN OPEN MIND; OUR HEARINGS MUST BE HONEST, FRANK AND FAIR. BUT WE WILL DRAW OUR OWN INDEPENDENT CONCLUSIONS. SHOULD WE FIND EVIDENCE OF MISMANAGEMENT, POOR JUDGMENT OR EVEN NEGLIGENCE, WE MUST TAKE APPROPRIATE ACTION.

IN THE FUTURE, WE MUST NEVER AGAIN ALLOW THE PREVIOUS SUCCESSES OF OUR SPACE PROGRAM TO BREED OVERCONFIDENCE. AS A COMMITTEE, WE MAY HAVE BEEN TOO TRUSTING IN THE PAST WHEN NASA GAVE US GLOWING, OPTIMISTIC

REPORTS ABOUT OUR SPACE PROGRAM. HINDSIGHT SUGGESTS THAT NASA'S VIEW OF THE SPACE SHUTTLE PROGRAM WAS NOT REALISTIC.

THIS NATION CANNOT ABANDON ITS SPACE PROGRAM. THE CHALLENGER ACCIDENT AND ITS AFTERMATH MARK A NEW BEGINNING, NOT AN END. IN THE PAST FOUR MONTHS, THIS NATION HAS LIVED THROUGH A VERY DIFFICULT TIME. THE TIME HAS NOW COME FOR ALL OF US TO PUT THE NATIONAL NIGHTMARE OF THE CHALLENGER BEHIND US. THE SEVEN BRAVE MEN AND WOMEN WHO REACHED FOR THE STARS AND--IN THE WORDS OF THE POEM--"TOUCHED THE FACE OF GOD" DESERVE NO LESS.

THANK YOU.

OPENING REMARKS OF

REPRESENTATIVE ROBERT S. WALKER

RANKING REPUBLICAN MEMBER
SUBCOMMITTEE ON SPACE SCIENCE
AND APPLICATIONS
UNITED STATES HOUSE OF REPRESENTATIVES

JUNE 10, 1986

Good morning, Mr. Chairman. This morning marks a tragic day for the committee and for the nation. Just over four months ago the people of the world were shocked to see the space shuttle Challenger lost with her crew of seven gallant Americans.

Today we begin the difficult duty of reviewing the work of the Rogers Commission to determine if we do, in fact, fully understand the cause of the Challenger accident. Once we satisfy ourselves that we understand exactly what happened, and why, then this committee will have to determine what our national policies will be in the wake of that disaster.

I must say that it appears that the Rogers Commission has done an excellent job and has set a new standard for Presidential Commissions. Considering the complexity of the Space Transportation System it was a major accomplishment for this commission to move as rapidly as they did to conduct a major investigation which isolated the field joint of the right SRB as the sole cause of this accident.

From a technical point of view I believe that we can be assured that the findings of the Commission are correct. I also fully support the recommendations of the Commission.

Specifically, I fully endorse the recommendations to:

* Redesign the field joints;
* Restructure management to be more responsive;
* Review fully the Critical Items List;
* Establish a meaningful safety organization; and
* Reduce the tremendous pressure on flight rates.

Mr. Chairman, NASA is an agency that has given this nation some of or most remarkable technical achievements. I have great confidence that we can solve the problems that caused this tragic accident. As we learned last week at the

Kennedy Space Center, the technical solutions are ones that we can resolve without too much difficulty. It will take time and money to fully understand the mechanics of the SRB joints, and to design a joint that we will all have confidence in. But we can clearly meet that requirement.

On the other hand, Mr. Chairman, it appears to me that some of the management difficulties that this commission has identified will take some time to resolve. Our Subcommittee on Space Science and Applications has already undertaken a major series of oversight hearings on some of these management issues. I am particularly concerned with the lack of an effective organization within the agency to guard safety, reliability and qualtiy assurance. There are indications other than the Challenger accident that lead me to believe that this is an area of major concern.

Mr. Chairman, I would like to commend Secretary Rogers, and the members of his commission, for a remarkable job which was accomplished under very trying circumstances. He has given us some clear guidelines which indicate the areas which we will have to concentrate on in the coming weeks.

OPENING STATEMENT

HON. F. JAMES SENSENBRENNER, JR.

FULL COMMITTEE HEARING

JUNE 10, 1986

THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY TO MAKE AN OPENING STATEMENT.

FIRST, I WELCOME MR. ROGERS AND MEMBERS OF THE COMMISSION WHO DILIGENTLY SERVED OUR COUNTRY IN THIS TIME OF NATIONAL TRAGEDY. THE COMMISSION HAS SET A NEW STANDARD OF EXCELLENCE IN CONDUCTING THIS COMPREHENSIVE INVESTIGATION OF THE CHALLENGER ACCIDENT. THE COMMISSION REPORT WAS PENETRATING, OBJECTIVE, AND CONCLUSIVE AS WELL AS PROMPTLY DELIVERED.

I THINK THE COMMISSION HAD THE PROPER OBJECTIVE WHICH WAS TO PREVENT ANY RECURRENCE OF THE FAILURE RELATED TO THIS ACCIDENT AND ALSO TO REDUCE OTHER RISKS IN FUTURE FLIGHTS. FROM THESE FINDINGS, I HOPE WE LEARN FROM OUR MISTAKES AND MOVE AHEAD TO OUR FAMILIAR POSITION AS THE WORLD'S LEADER IN SPACE. AS RONALD REAGAN SAID WHEN REFERRING TO THE CHALLENGER ACCIDENT "THE FUTURE IS NOT FREE: THE STORY OF ALL HUMAN PROGRESS IS ONE OF A STRUGGLE AGAINST ALL ODDS. WE LEARNED AGAIN THAT THIS AMERICA, WHICH ABRAHAM LINCOLN CALLED THE LAST, BEST HOPE OF MAN ON EARTH, WAS BUILT ON HEROISM AND NOBLE SACRIFICE. IT WAS BUILT BY MEN AND WOMEN LIKE OUR SEVEN STAR VOYAGERS, WHO ANSWERED A CALL BEYOND DUTY, WHO GAVE MORE THAN WAS EXPECTED OR REQUIRED AND WHO GAVE IT

LITTLE THOUGHT OF WORLDLY REWARD." MR. CHAIRMAN, THE ONLY FITTING TRIBUTE TO THE CREW OF SEVEN AND THEIR FAMILIES IS TO MOVE AHEAD TO FUTURE CHALLENGES IN SPACE.

OPENING STATEMENT
HON. SHERWOOD BOEHLERT (R-NY)
HEARING ON THE REPORT OF THE PRESIDENTIAL COMMISSION ON THE CHALLENGER ACCIDENT

JUNE 10, 1986

MR. CHAIRMAN:

I WANT TO APPLAUD SECRETARY ROGERS AND THE ENTIRE COMMISSION FOR THEIR PAINSTAKING EFFORTS TO UNCOVER THE CAUSE OF THE CHALLENGER TRAGEDY. THE COMMISSION HAS QUITE DESERVEDLY WON THE ADMIRATION OF THE CONGRESS AND THE AMERICAN PEOPLE FOR ITS THOROUGHNESS, ITS INTELLIGENCE AND ITS INTEGRITY. THE COMMISSION'S RECOMMENDATIONS, WHEN IMPLEMENTED, SHOULD RESTORE FAITH IN THE SPACE PROGRAM AND PREVENT FUTURE LOSS OF LIFE.

THE COMMISSION WAS SO EFFECTIVE PRECISELY BECAUSE IT AVOIDED THE FAULTS IT EXPOSED IN NASA. WHILE NASA HAD BECOME ALMOST CAVALIER ABOUT FACTS, THE COMMISSION PAID ATTENTION TO EVERY DETAIL. WHILE NASA HAD BEGUN TO SUBORDINATE SAFETY TO OTHER CONCERNS, THE COMMISSION MADE SAFETY THE FOCUS OF ITS INVESTIGATION. WHILE NASA'S PROCEDURES HAD BECOME COMPRESSED AND RUSHED, THE COMMISSION TOOK CARE TO BE THOROUGH AND DELIBERATE. AND WHILE NASA'S INTERNAL COMMUNICATIONS HAD BEGUN TO DETERIORATE, THE COMMISSION SET A STANDARD FOR RESPONSIBLE DEBATE.

OUR COMMITTEE MUST ASPIRE TO MEET THE EXACTING STANDARDS EPITOMIZED BY THE ROGERS COMMISSION. WE MUST REVIEW IT FINDINGS FULLY. WE MUST RESTORE FAITH IN AMERICA'S SPACE PROGRAM BY RESTORING ITS QUALITY AND ITS SAFETY. THAT WILL TAKE MORE THAN WORDS.

I LOOK FORWARD TO WORKING WITH MY COLLEAGUES TO MEET THAT CHALLENGE.

THE HONORABLE TOM LEWIS
STATEMENT
HEARING ON CHALLENGER INVESTIGATION
JUNE 10, 1986

THE COMMISSION HAS FINISHED ITS WORK AND I BELIEVE IT IS NOW APPROPRIATE FOR CONGRESS TO REVIEW THEIR FINDINGS AND RECOMMENDATIONS. I WANT TO COMMEND CHAIRMAN FUQUA FOR HIS LEADERSHIP DURING THESE TRYING TIMES. THIS COMMITTEE HAS HAD MORE THAN A CASUAL INTEREST IN DETERMINING THE CAUSE OF THE CHALLENGER ACCIDENT; HOWEVER, IT WAS IMPORTANT THAT THE COMMISSION BE ALLOWED TO CONDUCT ITS INVESTIGATION WITHOUT CONGRESSIONAL INTERFERENCE.

I HAVE READ THE COMMISSION'S REPORT, AND IT APPEARS THAT THEY HAVE BEEN THOROUGH AND PROFESSIONAL IN THEIR INVESTIGATION OF THE ACCIDENT AND THE EVENTS LEADING UP TO IT. IT IS WITH GREAT SADNESS THAT I HAVE TO CONCLUDE THAT SERIOUS PROBLEMS EXISTED WITHIN NASA, AND THIS TERRIBLE TRAGEDY PROBABLY DID NOT HAVE TO HAPPEN.

BUT BEFORE WE RUSH TO JUDGEMENT, I THINK WE ALSO NEED TO ASK OURSELVES WHAT PART WE PLAYED IN THIS TRAGEDY. AREN'T WE AT LEAST PARTLY RESPONSIBLE FOR HELPING TO CREATE THE ENVIRONMENT WHERE SERIOUS PROBLEMS SUCH AS THE FAULTY DESIGN OF THE SOLID ROCKET BOOSTER COULD BE OVERLOOKED ------ OR EVEN COVERED UP?

I BELIEVE WE WERE LULLED INTO A SENSE OF OVERCONFIDENCE IN NASA'S ABILITY TO ACCOMPLISH THE SPECTACULAR AND MAKE IT LOOK ROUTINE. NASA CREATED FOR ITSELF A REPUTATION FOR EXCELLENCE THAT WE FOUND DIFFICULT TO CHALLENGE. PERHAPS WE WANTED TOO MUCH TO BELIEVE IN NASA'S INVINCIBILITY, OR PERHAPS WE FELT INCOMPETENT TO CRITIQUE OUR HEROES. WHATEVER THE REASONS, WE MUST ACCEPT PART OF THE RESPONSIBILITY AND RECOGNIZE THE NEED FOR A MORE CRITICAL OVERSIGHT ROLE IN THE FUTURE. THE LEADERSHIP OF DR. FLETCHER WILL BE TESTED MANY TIMES OVER THE COMING MONTHS, BUT I AM CONFIDENT HE WILL MEET THE CHALLENGE.

I APPLAUD OUR CHAIRMAN'S POSITIVE SPIRIT IN CALLING FOR A NEW BEGINNING, AND I SHARE HIS CONFIDENCE THAT WE CAN LEARN FROM THIS TERRIBLE TRAGEDY AND BUILD AN EVEN STRONGER SPACE PROGRAM. TO DO LESS WOULD BE AN INSULT TO THOSE BRAVE ASTRONAUTS WHO GAVE THEIR LIVES FOR THIS PROGRAM.

OPENING REMARKS OF
HONORABLE DON RITTER

COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JUNE 10, 1986

Good morning, Mr. Chairman. I want to join my colleagues in welcoming Secretary Rogers and Mr. Armstrong before the Committee today. I, too, believe that the Rogers Commission has done an excellent job in their investigation of the tragic loss of Challenger and her gallant crew.

I believe that it is crucial that the White House and the Congress move quickly to resolve the issues raised by the Rogers Commission so that we may return to flight status as quickly as possible.

A few days ago I had the pleasure of hearing Scott Carpenter, one of our original seven astronauts, who was speaking in my district. I was quite impressed with his memories of space flight and with his point that from space there are no national boundaries. I have heard that virtually all space voyagers return to our fragile spaceship Earth impressed with the concept that space is an area that needs to be peacefully opened to everyone for science and commercialization.

The United States has built a solid international reputation as the world leader in manned space exploration. With the current situation in which we are temporarily unable to launch the shuttle for manned space flight, or either our Air Force Titan unmanned rocket, or NASA's highly dependable Delta unmanned rocket, we are in real danger of losing our international leadership position in space.

I think that it is important that this committee act quickly to complete our review of the Rogers Commission report, and then to give NASA the direction it needs to return us to flight. Let us learn from the lessons of the past, and get on with the future.

HONORABLE RON PACKARD
OPENING STATEMENT ON THE
CHALLENGER ACCIDENT
COMMITTEE ON SCIENCE AND TECHNOLOGY
JUNE 10, 1986

I COMMEND SECRETARY ROGERS AND THE OTHER MEMBERS OF THE PRESIDENTIAL COMMISSION INVESTIGATING THE CHALLENGER ACCIDENT FOR THEIR DILIGENCE, THOROUGHNESS AND OBJECTIVITY.

IN REVIEWING THE COMMISSION'S REPORT AND IN SPEAKING WITH NASA OFFICIALS, I AM STRUCK BY THE FEELING THAT THERE IS A SIGNIFICANT DIFFERENCE BETWEEN THE COMMISSION'S AND NASA'S PERCEPTION OF THE TECHNICAL AND MANAGEMENT EVENTS THAT LED TO THE ACCIDENT. NASA'S ATTITUDE DURING THE INVESTIGATION HAS CONVEYED THE MESSAGE THAT THE ACCIDENT WAS UNAVOIDABLE. I STRONGLY DISAGREE. I SUPPORT THE COMMISSION'S FINDING THAT THE CHALLENGER ACCIDENT WAS PREVENTABLE. I AM GRAVELY CONCERNED THAT NASA MAY NOT EVEN YET REALIZE THE SERIOUS MANAGEMENT PROBLEMS THAT HAVE DEVELOPED OVER THE YEARS AND PERMITTED SUCH AN ACCIDENT TO OCCUR. MY GREATEST FEAR IS WONDERING HOW MANY OTHER ACCIDENTS ARE WAITING TO HAPPEN.

IN THE SAME WAY, CONTRACTORS WITHIN THE PROGRAM MUST BE HELD ACCOUNTABLE AND LEARN THE HARD LESSONS OF THE PAST FIVE MONTHS. IT IS NOT ENOUGH FOR US TO ESTABLISH CULPABILITY; WE MUST RESTORE

THE FAITH THAT HAS BEEN LOST IN RECENT MONTHS BY CHANGING THE MANAGEMENT POLICY.

IT IS NOW THIS COMMITTEE'S RESPONSIBILITY TO ASSESS THE COMMISSION'S FINDINGS AND RECOMMENDATIONS, REVIEW THE ENTIRE NATIONAL SPACE TRANSPORTATION SYSTEM, AND IMPLEMENT COMMISSION AND COMMITTEE RECOMMENDATIONS TO ENSURE THAT NO MORE "PREVENTABLE" ACCIDENTS WILL OCCUR. FURTHER, THE COMMITTEE MUST BE MORE DILIGENT IN ITS OVERSIGHT.

OUR MANNED SPACE PROGRAM HAS GREATLY BENEFITED THIS NATION AND THE WORLD. AS THIS COMMITTEE REVIEWS AND FURTHER INVESTIGATES THE ACCIDENT AND NASA, WE MUST NOT, IN OUR ZEAL TO REPRIMAND AND CORRECT PROBLEMS, DESTROY NASA. RATHER, WE MUST REPAIR AND RESTORE NASA TO THE GREAT ORGANIZATION THAT IT HAS BEEN AND IS CAPABLE OF BEING AGAIN. THE CONFIDENCE AND HIGH LEVEL OF SUPPORT FOR NASA AND THE SPACE PROGRAM BY THIS COMMITTEE, THE CONGRESS, AND THE NATION AT LARGE MUST BE RETAINED.

OPENING REMARKS OF REPRESENTATIVE ROBERT C. SMITH (N.H.-1)
SCIENCE AND TECHNOLOGY HEARINGS ON THE REPORT OF THE PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT
JUNE 10, 1986

The First Teacher chosen for Space Flight, Christa McAuliffe, is deeply missed in our home state of New Hampshire. As we commence this series of hearings on the Challenger accident, I believe that there could be no finer tribute to the memory of Christa and her six fellow Challenger crew members than to rededicate ourselves to the pursuit of space flight.

We must find the problem, fix it and go on. Chairman Rogers and the Presidential Commission on the Space Shuttle Challenger Accident have had a difficult, challenging task and they have done outstanding work. The Rogers Commission report is a critical, but fair, document. Its clarity and findings will prove of great assistance to this Committee as we determine how to fix serious safety and communications problems and continue with the Space Shuttle Program.

As a relatively new member of the Space Science and Applications Subcommittee, I am extremely concerned with the previous lack of testimony by NASA witnesses in subcommittee hearings on problems of safety and the effect of budget constraints on this crucial aspect of the Shuttle Program. I want to see future Space Science and Applications Subcommittee hearings prioritize improved safety oversight. Particularly disturbing is that Shuttle launches were not delayed voluntarily by NASA when the design of the Solid Rocket Motor joint was suspected as faulty, and the fact that, as members of the Committee which has jurisdiction over NASA, we were never made aware of this design deficiency by NASA. In addition, I am stunned that this design concern might even have failed to reach the appropriate NASA management officials. If this is the case, then Congress must oversee a restructuring of NASA's communication system.

We must translate our attitude of concern for the lives and complex hardware at risk every time we launch into real safety precautions and careful management decisions, or we might as well stay on the ground. The greatest good which could come out of this and future Congressional oversight is to see that success in space does not again lead to compromises in safety.

OPENING COMMENTS OF CONGRESSMAN JOE BARTON

SCIENCE AND TECHNOLOGY COMMITTEE HEARING

REPORT OF THE PRESIDENTIAL COMMISSION ON THE CHALLENGER ACCIDENT

JUNE 10, 1985

Mr. Chairman, I commend the work of Chairman Rogers and the other members of the Presidential Commission on the Space Shuttle Challenger Accident. In the aftermath of the worst disaster in the history of space exploration, the Presidential Commission has pursued its mandate with hard work and determination.

All too often, commissions and blue ribbon panels which are established are paper organizations which meet infrequently to approve work done by staff. This commission, under the leadership of Chairman Rogers, has been an actual working group utilizing the exceptional talents of its membership to discover the cause of the shuttle tragedy and make recommendations to prevent its recurrence. There is no doubt that the commission has determined the cause of the explosion and made a number of insightful recommendations to insure that this never recurs again.

The findings and recommendations of the Commission are an excellent starting point from which to begin efforts to solve the problems at NASA and the Shuttle program. The design of the Solid Rocket Motor joint is an obvious area which deserves our greatest attention and efforts. Involving the astronauts in the design and management of the shuttle programs is also a needed reform. The Apollo program was characterized by close cooperation between the engineers and the Astronaut office. It is no coincidence that the

Apollo program was a paragon of excellence which NASA would do well to emulate today.

I would like to see the Science and Technology Committee address other issues as we conduct our oversight hearings of the Rogers Commission report. The first is the issue of NASA leadership. It is clear that NASA has moved from an organization focused on research and development oriented towards single missions to an organization focused on operations and multiple missions. In doing so, it has failed to maintain the standards of excellence which marked its earlier days.

The Rogers Commission has detected a pattern of behavior at NASA that overlooked known potential safety problems. The list of components on the shuttle which were assigned "Criticality 1" (that is components with no backup whose failure would cause the loss of life or vehicle) is staggering. 748 items are listed as Criticality 1! The question which comes to mind is not why the tragedy occurred, but why it did not occur sooner.

One problem that has dogged NASA from the beginning of the shuttle program is that it was oversold to Congress. At one point prior to beginning shuttle flights, NASA estimated that they could eventually fly one shuttle flight a week. NASA later downgraded this estimate to two flights per month. The most flights that NASA has ever flown in a 12 month period, however, is nine. Combined with cost figures which have been consistently underestimated, it is not surprising that there has been tremendous pressure on NASA to increase the number of flights to justify the tremendous investment in the shuttle.

The multiple pressures on NASA — budgetary, scheduling, personnel, and payload needs — will not decrease in the years ahead. For this reason, NASA needs strong and effective leadership beginning at the top and extending down through the entire organization. This type of leadership will help insure that NASA regains the excellence which was once the hallmark of the agency.

Another major area of concern is the replacement for the shuttle. It is certain that we need a replacement for the orbiter. Some have testified before this Committee that "the taxpayer should pay for the next shuttle." I cannot support this viewpoint. I will be working to discover innovative means to finance the next shuttle. I hope that we can gather a coalition of public and private groups willing to work together to fund and build the next shuttle. With public tax dollars becoming increasingly precious, now is the time to seriously address partial private financing.

An additional issue is what level of technology to utilize in the new orbiter. Short term considerations would seem to dictate building a replacement orbiter identical in most respects to the existing three orbiters. However, it might be wise to employ the next generation of technology in a replacement orbiter. I look forward to discussing these concerns with NASA officials and other experts in the coming weeks.

The shuttle tragedy has forever changed the way we perceive our space program. We can no longer not take our access to space for granted. We must critically review the space program and insure that a disaster such as this is never repeated. The American space program is essential for the future of this country. Our national pride and world technological leadership are resting on the resumption of space flight and a strong national space program.

The Chair wants to advise the members that our plan for the conduct of the hearings will be to hear from our distinguished witnesses today, this morning until noontime. We will reconvene tomorrow with representatives testifying from NASA. We will reconvene again on Thursday with Secretary Rogers and his associates coming back here, and we'll reconvene again on Friday with NASA to follow up from there. That is the plan for the week, so you can plan your schedules accordingly.

The Chair would like to again welcome Secretary Rogers and Mr. Armstrong, the vice chairman, to our hearings, and Dr. Keel, and again compliment you on the extraordinary work that you have done.

And we defer directly to you, Mr. Secretary, for your opening statements and any comments you may wish to make. Mr. Secretary?

STATEMENT OF HON. WILLIAM P. ROGERS, CHAIRMAN, PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE "CHALLENGER" ACCIDENT, ACCOMPANIED BY NEIL A. ARMSTRONG, VICE CHAIRMAN

Mr. ROGERS. Thank you, Mr. Chairman, members of the committee.

First, I would like to begin by expressing my gratitude and the gratitude of——

Mr. ROE. Mr. Secretary, could you please pull that microphone closer? It's a little bit hard to hear.

Mr. ROGERS. How's that?

Mr. ROE. That's better.

Mr. ROGERS. Is that OK now?

Mr. ROE. Fine. Thank you.

Mr. ROGERS. I'll start again.

I would like to express my gratitude and that of the Commission for your support and cooperation throughout this investigation. You have allowed the Commission the opportunity to proceed with its very important and very often difficult task without interference of any kind, and you deserve acknowledgment and recognition for doing so.

As you know, from time to time I briefed the members of the committee about our work. I am pleased to say that those briefings were conducted in private session. All of the information that we conveyed was held by the committee. There were no leaks from the committee. And all of us appreciate the fact that you cooperated as you did.

And we recognize that it's now the right and the responsibility of Congress—and you see in our preface we point that out—to conduct the hearings that you deem appropriate. We fully support and welcome such hearings.

I have a prepared statement here which in a sense is a summary of the recommendations in the report itself. I don't think it's necessary for me to read that statement. I'll be glad to submit it for the record. I thought the committee should have it for the record, but I don't think it's necessary because it's pretty much repetitious.

Mr. ROE. With no objection, so agreed.

[The prepared statement of Mr. Rogers follows:]

Testimony of

William P. Rogers
Chairman, Presidential Commission on the
Space Shuttle Challenger Accident

on the

Report to the President by the
Presidential Commission

before the

House Committee on Science and Technology

June 10, 1986

Mr. Chairman, I would like to begin by expressing my gratitude and appreciation to you and your Committee for your support and cooperation throughout the Commission investigation. You allowed the Commission the opportunity to proceed with its very important, and often difficult task, without interference of any kind. You deserve acknowledgment and recognition for doing so. The Commission recognizes that it's now the right and responsibility of Congress in its oversight role to conduct hearings as it deems appropriate. We fully support and welcome such hearings.

I would like to begin, Mr. Chairman, by providing the Committee a sense of the scope of our investigation and a description of the Commission approach to the investigation as events unfolded.

I will then give you a brief description of the accident and explanation of the cause as determined by the Commission. I will relate our findings regarding the launch decision process, and the history of concerns about the design and flight experience with the Solid Rocket Booster joints and O-ring seals. Finally, I will discuss Commission findings regarding the NASA safety organization, launch pressures on the system, and other future safety concerns -- including those brought to the Commission's attention by the Astronaut office.

I will conclude with a summary of our recommendations to avoid a future recurrence of a tragedy such as the Challenger accident, and to return our nation to safe space flight.

Scope of Investigation

We believe the investigation and report is one of the most comprehensive and complete of its kind.

-- Seventy witnesses testified before the full Commission, providing 2,800 pages of transcript.

-- More than 160 individuals were interviewed and 46 Commission panel sessions were conducted, yielding 12,000 pages of transcript.

-- Over 6,300 reports and documents were reviewed, totaling more than 122,000 pages.

-- 33 NASA Task Force Reports were prepared -- in part by Commission Panel members -- and submitted to the Commission for review and analysis.

All materials relating to the investigation, including private correspondence, were documented, reviewed, and evaluated and made a part of the computerized data base. Commission materials will now become part of the permanent public record.

The Commission Report is a complete and careful presentation of the facts revealed by the investigation and of the Commission findings and recommendations based on those facts. Four additional volumes of supporting information are being published: two volumes of supplemental reports, including the six NASA Team Reports; and two volumes of Commission Hearing Transcripts.

Commission Activities

•President Reagan, seeking to ensure a thorough and unbiased investigation of the Challenger accident, announced the formation of the Commission on February 3, 1986. The mandate given by the President, contained in Executive Order 12546, required Commission members to:

(1) Review the circumstances surrounding the accident to establish the probable cause or causes of the accident; and

(2) Develop recommendations for corrective or other action based upon the Commission's findings and determinations.

Following its swearing in on February 6, the Commission immediately began a series of hearings during which NASA officials outlined agency procedures covering the Shuttle program and the status of NASA's investigation of the accident.

Shortly thereafter, on February 10, Dr. Alton G. Keel, Jr., Associate Director of the Office of Management and Budget, was appointed Executive Director. Dr. Keel began gathering a staff of 15 experienced investigators as well as administrative personnel from various government agencies and the military services.

Eventually, 42 permanent staff personnel, including administrative and writing support were assembled. Over 100 additional contract personnel were assembled to staff the Commission document control center -- to enter documents into the computer data base, and to assist Commissioners and staff in conducting computer searches of Commission documents.

During a closed session on February 10, 1986, the Commission began to learn of the troubled history of the Solid Rocket Motor joints and seals. Moreover, it discovered the first indication that the contractor, Morton Thiokol, initially recommended against launch on January 27, 1986, the night before the launch of 51-L, because of concerns regarding low temperature effects on the joint and seal. To investigate this disturbing development, additional closed sessions were scheduled for February 13 and 14 at Kennedy. The February 13, 1986, session was an extensive presentation of film, video, and telemetry data relating to the Challenger accident. It provided the Commission the first evidence that the Solid Rocket Motor joint and seal may have malfunctioned, initiating the accident.

The session on February 14 included NASA and contractor participants involved in the discussion on January 27, 1986, not to launch 51-L. After testimony was received, an executive session of the Commission was convened. The following statement was subsequently issued on February 15, 1986, reflecting the conclusion and view of the Commission.

> "In recent days, the Commission has been investigating all aspects of the decision making process leading up to the launch of the Challenger and has found that the process may have been flawed. The President has been so advised.
>
> "Dr. William Graham, Acting Administrator of NASA, has been asked not to include on the internal investigating teams at NASA, persons involved in that process.
>
> "The Commission will, of course, continue its investigation and will make a full report to the President within 120 days."

The role of the Commissioners thus changed from that of overseers to that of active investigators and analysts of data presented by NASA and its contractors.

By February 17, the Commission had divided itself into four investigative panels. Working groups were sent to Marshall, Kennedy, and Thiokol to analyze data relating to the accident and to redirect efforts. NASA's investigation was also reorganized to reflect the structure of the Commission's panels.

The Accident Analysis Panel, chaired by Major General Donald Kutyna, made several trips to both Kennedy and Marshall and traveled to Thiokol facilities in Utah to review photographic and telemetric evidence as well as the results of the salvage operation and to oversee the tests being conducted by NASA and Thiokol engineers.

Early in March, at my request, this group assembled and directed the Commission's independent team of six technical observers with extensive experience in Solid Rocket Motor technology and accident investigation to validate and interpret the tests and analyses performed on the Thiokol motor by NASA and Thiokol.

The Development and Production Panel, chaired by Joseph Sutter, centered its investigation on the production and testing activities of the Shuttle element contractors.

The Pre-Launch Activities Panel, chaired by David Acheson, concentrated on activities at Kennedy where the Shuttle elements are assembled and all other final launch preparations are completed.

The Mission Planning and Operations Panel, chaired by Dr. Sally Ride, focused its efforts on mission planning and crew preparation for STS 51-L and on details of NASA's safety, reliability, and quality assurance programs.

While the work of the individual panels and their investigative staffs was ongoing, the Commission's general investigative staff began a series of individual interviews to document fully the factual background of various areas of the Commission's interest, including the telecon between NASA and Thiokol officials the night before the launch; the history of joint design and O-ring problems; NASA safety, reliability and quality assurance functions; and the assembly of the right Solid Rocket Booster for STS 51-L. Subsequent investigative efforts by this group were directed in the area of the effectiveness of NASA's organizational structure, particularly the Shuttle program structure, and allegations that there had been external pressure on NASA to launch on January 28th.

In addition to the work of the Commission and the Commission staff, NASA personnel expended a vast effort in the investigation. More than 1,300 employees from all NASA facilities were involved and were supported by more than 1,600 people from other government agencies and over 3,100 from NASA's contractor organizations. Particularly significant were the activities of the military, the Coast Guard and the National Transportation Safety Board in the salvage and analysis of the Shuttle wreckage.

Description of the Accident.

Based on film, video and telemetry data, the Commission determined that the sequence of events leading to the accident was as follows:

-- Liftoff began with the ignition of the Solid Rocket Boosters, (6.6 seconds after ignition of the Space Shuttle Main Engines).

-- At .678 seconds after liftoff, the first puff of smoke was observed emanating from the right Solid Rocket Booster in the vicinity of the aft field joint between the booster and the External Tank, near the External Tank attach strut.

-- By 2.5 seconds after liftoff the generation of the smoke stopped. About nine puffs of smoke had been generated.

-- During the ascent -- beginning at about 37 seconds and lasting until about 64 seconds -- heavy wind shears were encountered that, although not producing excessive loads, did provide a "bumpy ride" that could have had an effect on an already damaged system; namely, the seal in the aft field joint.

-- Everything looked normal until about 59 seconds after liftoff. At this time flame started coming out of the right booster in the area where smoke had been seen before.

-- The flame and hot gas plume grew in size during the next 14 to 15 seconds. It was impinging on the aft (hydrogen tank portion) of the External Tank close to where the tank is connected to the Solid Rocket Booster.

-- At about 64 to 65 seconds the structural integrity of the External Tank was breached and hydrogen began leaking from the aft region near a welded seam.

-- Beginning at about 72 seconds, a rapid sequence of events began. The heat and flame weakened connection (strut) to the lower part of the External Tank failed. At about 73 seconds, the bottom portion of the External Tank (hydrogen tank) failed.

-- Failure of the bottom of the External Tank caused the pressurized liquid hydrogen to be released rapidly, which in turn propelled the hydrogen tank, with about 2.8 million pounds of force, into the intertank area (between hydrogen and oxygen tanks), and probably into the bottom of the oxygen tank (upper portion of External Tank).

-- At about the same time, the forward part of the booster (frustum) impacted with the forward part of the External Tank, which contained the oxygen tank. Failure of the aft booster attachment strut had allowed the bottom part of the booster to move away from the External Tank, rotating about its forward attachment point.

-- This nearly instantaneous mixing of hydrogen and oxygen, in an environment of sparks produced when the hydrogen tank was propelled into the intertank area, caused a fire, or nearly explosive burning of these propellants. The Orbiter, under severe aerodynamic loads, broke into pieces within fractions of a second.

The Shuttle was going at nearly twice the speed of sound (Mach 1.92) and was passing through 46,000 feet of altitude. There were no alarms sounded in the cockpit. The crew apparently had no indication of a problem before the rapid break-up of the Space Shuttle system. The first evidence of an accident came from live video coverage. Radar then began to track multiple objects. The flight dynamics officer in Houston confirmed to the flight director that "RSO (range safety officer) reports vehicle exploded," and 30 seconds later he added that the range safety officer had sent the destruct signal to the Solid Rocket Boosters. During the period of flight when the Solid Rocket Boosters are thrusting, there are no survivable abort options. There was nothing that either the crew or the ground controllers could have done to avert the catastrophe.

Cause of the Accident

The consensus of the Commission and participating investigative agencies is that the loss of the Space Shuttle Challenger was caused by a failure in the joint between the two lower segments of the right Solid Rocket Motor. The specific failure was the destruction of the seals that are intended to prevent hot gases from leaking through the joint during the propellant burn of the rocket motor. The evidence assembled by the Commission indicates that no other element of the Space Shuttle system contributed to this failure.

In arriving at this conclusion, the Commission reviewed in detail all available data, reports, and records; directed and supervised numerous tests, analyses, and experiments by NASA, civilian contractors and various government agencies; and then developed specific failure scenarios and the range of most probable causative factors.

Throughout the investigation three critical questions were central to the inquiry, namely:

-- What were the circumstances surrounding mission 51-L that contributed to the catastrophic termination of that flight in contrast to 24 successful flights preceding it?

-- What evidence pointed to the right Solid Rocket Booster as the source of the accident as opposed to other elements of the Space Shuttle?

-- Finally, what was the mechanism of failure?

Using mission data, subsequently completed tests and analyses, and recovered wreckage, the Commission identified all possible faults that could originate in the respective flight elements of the Space Shuttle which might have the potential to lead to loss of the Challenger. Potential contributors to the accident examined by the Commission were the launch pad, the External Tank, the Space Shuttle Main Engines, the Orbiter and related equipment, payload/Orbiter interfaces, the payload, the Solid Rocket Boosters and Solid Rocket Motors.

In a parallel effort, the question of sabotage was examined in detail and reviewed by the Commission in executive session. There is no evidence of sabotage, either at the launch pad or during other processes prior to or during launch.

As the investigation progressed, elements assessed as being improbable contributors to the accident were eliminated from further consideration. This process of elimination brought focus to the right Solid Rocket Motor. As a result, four areas related to the functioning of that motor received detailed analysis:

- Structural Loads
- Failure of the Case Wall (Case Membrane)
- Propellant Anomalies
- Loss of the Pressure Seal at the Case Joint

Through analysis, supporting data based on the investigation and tests, the Commission concluded that structural loads at launch or during flight, that flaws in the case membrane, or propellant anomalies were not the cause of the accident.

In contrast, joint seal failure was suspect. Enhanced photographic and computer-graphic positioning determined that the flame from the right Solid Rocket Booster near the aft field joint emanated at about the 305-degree circumferential position. The smoke at lift off appeared in the same general location. Thus, early in the investigation, the right Solid Rocket Booster aft field joint seal became the prime failure suspect. This supposition was confirmed when the Salvage Team recovered portions of both sides of the aft joint containing large holes extending from 291 degrees to 318 degrees.

Based on extensive tests and analyses, the investigation has shown that the joint sealing performance is sensitive to the following factors:

(a) Damage to the joints/seals or generation of contaminants as joints are assembled.

(b) Tang/clevis gap opening due to motor pressure and other loads.

(c) Static O-ring compression.

(d) Joint temperature as it affects O-ring response and hardness and formation of ice in the joint.

(e) Use of putty as a thermal barrier as it relates to O-ring pressure actuation timing and O-ring erosion.

The Commission concluded that the joint/seal design was faulty, and overly sensitive to the above factors, and that as a consequence the joint malfunctioned, initiating the Challenger accident. In summary, the specific findings of the Commission with aspect to the cause of the accident are as follows:

(1) A combustion gas leak through the right Solid Rocket Motor aft field joint initiated at or shortly after ignition eventually weakened and/or penetrated the External Tank initiating vehicle structural breakup and loss of the Space Shuttle Challenger during STS Mission 51-L.

(2) The evidence shows that no other STS 51-L Shuttle element or the payload contributed to the causes of the right Solid Rocket Motor aft field joint combustion gas leak. Sabotage was not a factor.

(3) Launch site records show that the right Solid Rocket Motor segments were assembled using approved procedures. However, significant out-of-round conditions existed between the two segments joined at the right Solid Rocket Motor aft field joint.

(4) The ambient temperature at time of launch was 36 degrees Fahrenheit, or 15 degrees lower than the next coldest previous launch. The calculated joint and O-ring temperature was 28 degrees or 25 degrees colder than any previous launch.

(5) Experimental evidence indicates that due to several effects associated with the Solid Rocket Booster's ignition and combustion pressures and associated vehicle motions, the gap between the tang and the clevis will open as much as .017 and .029 inches at the secondary and primary O-rings, respectively.

(6) A compressed O-ring at 75 degrees Fahrenheit is five times more responsive in returning to its uncompressed shape than a cold O-ring at 30 degrees Fahrenheit. As a result, it is probable that the O-rings in the right solid booster aft field joint were not following the opening of the gap between the tang and clevis at time of ignition.

(7) Experiments indicate that the primary mechanism that actuates O-ring sealing is the application of gas pressure to the upstream (high pressure) side of the O-ring as it sits in its groove or channel. A tang-to-clevis gap of .004 inches, as probably existed in the failed joint, would have initially compressed the O-ring to the degree that no clearance existed between the O-ring and the walls and bottom surface of the channel. At the cold launch temperature experienced, the O-ring would be very slow in returning to its normal rounded shape and it would remain in its compressed position in the O-ring channel unable to follow the gap opening. Thus, it is probable the O-ring would not be pressure actuated to seal the gap in time to preclude joint failure, resulting from blow-by and O-ring erosion from hot combustion gases.

(8) Experimental evidence indicates that temperature, humidity, and other variables in the putty compound used to seal the joint can delay pressure application to the joint by 500 milliseconds or more.

(9) Of 20 launches with calculated joint temperatures of 66 degrees Fahrenheit or greater, only three showed signs of O-ring thermal distress; i.e., erosion or blow-by and soot. Each of the four launches with joint temperature at 63 degrees or below resulted in one or more O-rings showing signs of thermal distress.

(10) At time of launch, it was cold enough that water present in the joint would freeze. Tests show that ice in the joint can inhibit proper secondary seal performance.

(11) A small leak could have persisted throughout the flight and grown to breach the joint in flame at a time on the order of 58 to 60 seconds after lift off. Alternatively, the O-ring gap could have been resealed by deposition of a fragile buildup of aluminum oxide and other combustion debris. This resealed section of the joint could have been disturbed by thrust vectoring, Space Shuttle motion and flight loads induced by changing winds aloft.

In conclusion, in view of the findings, the Commission concluded that the cause of the Challenger accident was the failure of the pressure seal in the aft field joint of the right Solid Rocket Motor. The failure was due to a faulty design unacceptably sensitive to a number of factors. These factors were the effects of temperature, physical dimensions, the character of materials, the effects of reusability, processing, and the reaction of the joint to dynamic loading.

Contributing Cause: Flawed Decision Process

In addition to analyzing all available evidence concerning the material causes of the accident on January 28, the Commission examined the chain of decisions that culminated in approval of the launch. It concluded that the decision to launch the Challenger was flawed. Those who made that decision were unaware of the recent history of problems concerning the O-rings and the joint and were unaware of the initial written recommendation of the contractor advising against the launch at temperature below 53 degrees Fahrenheit and the continuing opposition of the engineers at Thiokol after the management reversed its position. They did not have a clear understanding of Rockwell's concern that it was not safe to launch because of ice on the pad. If the decision makers had known all of the facts, it is highly unlikely that they would have decided to launch 51-L on January 28, 1986.

Commission testimony reveals failures in communication that resulted in a decision to launch 51-L based on incomplete and sometimes misleading information, a conflict between engineering data and management judgments, and a NASA management structure that permitted internal flight safety problems to bypass key Shuttle managers.

Specifically, the launch decision makers for flight 51-L were not made aware of the lengthy discussion during teleconferences of the concerns of Thiokol engineers relative to the effects of the cold temperatures predicted for launch on the ability of the O-rings in the Solid Rocket Motor joints to respond rapidly enough to seal the joints. They were unaware that Thiokol, including management officials, originally recommended not to launch and then, when pressed by NASA, that Thiokol management reassessed and recommended to launch.

The Commission consquently concluded that the launch decision process was seriously flawed. Had the concerns of most Thiokol engineers, and some Marshall engineers, been conveyed to launch decision makers, it seems likely that the launch of 51-L might not have occurred when it did.

The Commission is troubled by what appears to be a propensity of management at Marshall to contain potentially serious problems and to attempt to resolve them internally rather than communicate them forward. This tendency is altogether at odds with the need for Marshall to function as part of a system working toward successful flight missions, interfacing and communicating with the other parts of the system that work to the same end.

The Commission also concluded that the Thiokol Management reversed its position and recommended the launch of 51-L, at the urging of Marshall and contrary to the views of its engineers in order to accommodate a major customer.

Also, the investigation revealed that although the freeze protection plan for the launch pad was "implemented," the water system was not drained because of the imminent launch of 51-L. In order to prevent pipes from freezing, a decision was made to allow water to run slowly from the system. This had never been done before, and the combination of freezing temperatures and stiff winds caused large amounts of ice to form below the 240-foot level of the fixed service structure, including the access to the crew emergency egress slide wire baskets.

These conditions were first identified by the Ice Team at approximately 2:00 a.m. on January 28 and were assessed by management and engineering throughout the night, culminating with a Mission Management Team meeting at 9:00 a.m. At this meeting, representatives for the Orbiter prime contractor, Rockwell International, expressed their concern about what effects the ice might have on the Orbiter during launch.

The decision was made to launch pending a final ice team review of the launch complex in order to assess any changes in the situation. This inspection was completed following the Mission Management Team meeting and the ice team report indicated no significant change.

An analysis of all the testimony and interviews establishes that Rockwell's recommendation to launch at the 9:00 A.M. meeting was ambiguous. The Commission finds it difficult, as did NASA, to conclude that there was a no-launch recommendation.

The Commission is concerned, however, about the NASA response to the Rockwell position. While it is understood that decisions have to be made in launching a Shuttle, the Commission is not convinced Levels I and II appropriately considered Rockwell's concern about the ice. However ambiguous Rockwell's position was, it is clear that they did tell NASA that the ice was an unknown condition. Given the extent of the ice on the pad, the Commission finds the decision to launch questionable under those circumstances. In this situation, NASA appeared to be requiring a contractor to prove that it was not safe to launch, rather than proving it was safe.

An Accident Rooted in History: A Faulty Design and Ignored Warnings

The Space Shuttle's Solid Rocket Booster problem began with the faulty design of its joint and increased as both NASA and contractor management first failed to recognize it as a problem, then failed to fix it, and finally treated it as an acceptable flight risk.

Morton Thiokol, Inc., the contractor, did not accept the implication of tests early in the program that the design had a serious and unanticipated flaw. NASA did not accept the judgment of its engineers that the design was unacceptable, and as the joint problems grew in number and severity NASA minimized them in management briefings and reports. Thiokol's stated position was that "the condition is not desirable but is acceptable."

Neither Thiokol nor NASA expected the rubber O-rings sealing the joints to be touched by hot gases of motor ignition, much less to be partially burned. However, as tests and then flights confirmed damage to the sealing rings, the reaction by both NASA and Thiokol was to increase the amount of damage considered "acceptable." At no time did management either recommend a redesign of the joint or call for the Shuttle's grounding until the problem was solved.

The Commission's review of the Marshall and Thiokol documentary presentations at the various Flight Readiness Reviews prior to Shuttle flights revealed several significant trends. First, O-ring erosion was not considered a problem early in the program when it first occurred. Second, when the problem grew worse after STS 41-B, the initial analysis of the problem did not produce much research; instead, there was an early acceptance of the phenomenon. Third, because of a belief that in-flight O-ring erosion was "within the data base" of prior experience, later Flight Readiness Reviews gave a cursory review and often dismissed the recurring erosion as within "acceptable" or "allowable" limits. Fourth, both Thiokol and Marshall continued to rely on the redundancy of the secondary O-ring long after NASA had officially declared that the seal was a non-redundant single point failure. Finally, in 1985 when temperature became a major concern after STS 51-C and when the launch constraint was applied after 51-B, NASA Levels I and II were not informed of these developments in the Flight Readiness Review process.

The Commission concluded that the genesis of the Challenger accident -- the failure of the joint of the right Solid Rocket Motor -- began with decisions made in the design of the joint and in the failure by both Thiokol and NASA's Solid Rocket Booster project office to understand and respond to facts obtained during testing.

The Commission also concluded that neither Thiokol nor NASA responded adequately to internal warnings about the faulty seal design. Furthermore, Thiokol and NASA did not make a timely attempt to develop and verify a new seal after the initial design was shown to be deficient. Neither organization developed a solution to the unexpected occurrences of O-ring erosion and blow-by even though this problem was experienced frequently during the Shuttle flight history. Instead, Thiokol and NASA management came to accept erosion and blow-by as unavoidable and an acceptable flight risk. Specifically, the Commission has found that:

-- The joint test and certification program was inadequate.

-- Prior to the accident, neither NASA nor Thiokol fully understood the mechanism by which the joint sealing action took place.

-- NASA and Thiokol accepted escalating risk as they began to consider flight "anomalies" as part of their "data base."

-- The O-ring erosion history presented to Level I at NASA Headquarters in August 1985 was sufficiently detailed to require corrective action prior to the next flight.

-- A careful analysis of the flight history of O-ring performance would have revealed the correlation of O-ring damage and low temperature.

The Silent Safety Program

The Commission was surprised to realize after many hours of testimony that NASA's safety staff or safety organization was never mentioned. No witness related the approval or disapproval of the reliability engineers, and none expressed the satisfaction or dissatisfaction of the quality assurance staff. No one thought to invite a safety representative or a reliability and quality assurance engineer to the January 27, 1986, teleconference between Marshall and Thiokol. Similarly, there was no representative of safety on the Mission Management Team that made key decisions during the countdown on January 28, 1986.

The unrelenting pressure to meet the demands of an accelerating flight schedule might have been adequately handled by NASA if it had insisted upon the exactingly thorough procedures that were its hallmark during the Apollo program. An extensive and redundant safety program comprising interdependent safety, reliability and quality assurance functions existed during and after the lunar program to discover any potential safety programs. Between that period and 1986, however, the program became ineffective. This loss of effectiveness seriously degraded the checks and balances essential for maintaining flight safety.

On April 3, 1986, Arnold Aldrich, the Space Shuttle program manager, appeared before the Commission at a public hearing in Washington, D.C. He described five different communication or organization failures that affected the launch decision on January 28, 1986. Four of those failures relate directly to faults within the safety program. These faults include a lack of program reporting requirements, inadequate trend analysis, misrepresentation of criticality and lack of involvement in critical discussions. A properly staffed, supported, and robust safety organization might well have avoided these faults and thus eliminated those communication failures.

NASA has a safety program intended to ensure that the communication failures to which Mr. Aldrich referred do not occur. In the case of mission 51-L, that program fell short.

Relative to the safety function, the Commission found that reductions in the safety, reliability and quality assurance work force at Marshall and NASA Headquarters have seriously limited capability in those vital functions. The independence of the safety organizations at Kennedy and Marshall is compromised, since those organizations are under the supervision of the very organization and activities whose efforts they are to check.

Pressures on the System

With the 1982 completion of the orbital flight test series, NASA began a planned acceleration of the Space Shuttle launch schedule. One early plan contemplated an eventual rate of a mission a week, but realism forced several downward revisions. In 1985, NASA published a projection calling for an annual rate of 24 flights by 1990. Long before the Challenger accident, however, it was becoming obvious that even the modified goal of two flights a month was overambitious.

In establishing the schedule, NASA had not provided adequate resources for its attainment. As a result, the capabilities of the system were strained by the modest nine-mission rate of 1985, and the evidence suggests that NASA would not have been able to accomplish the 15 flights scheduled for 1986.

One effect of NASA's accelerated flight rate and the agency's determination to meet it was the dilution of the human and material resources that could be applied to any particular flight. The part of the system responsible for turning the mission requirements and objectives into flight software, flight trajectory information and crew training materials was struggling to keep up with the flight rate in late 1985, and forecasts showed it would be unable to meet its milestones for 1986. With respect to the flight rate pressures the Commission found:

-- The capabilities of the system were stretched to the limit to support the flight rate in the winter of 1985/1986.

-- The Shuttle program made a conscious decision to postpone spare parts procurements in favor of budget items of perceived higher priority. Lack of spare parts would likely have limited flight operations in 1986.

-- Stated cargo and crew manifest policies are not enforced. Numerous late manifest changes have been made to both major payloads and minor payloads, and in payload specialists, throughout the Shuttle program.

Outside Pressure to Launch

After the accident, rumors appeared in the press to the effect that persons who made the decision to launch mission 51-L might have been subjected to outside pressure to launch. Such rumors concerning unnamed persons, emanating from anonymous sources about events that may never have happened, are difficult to disprove and dispel. Nonetheless, during the Commission's hearings all persons who played key roles in that decision were questioned. Each one attested, under oath, that there had been no outside intervention or pressure of any kind leading up to the launch.

One rumor was that plans had been made to have a live communication hookup with the 51-L crew during the State of the Union Message. Commission investigators interviewed all of the persons who would have been involved in a hookup if one had been planned, and all stated unequivocally that there was no such plan.

The Commission thus concluded that the decision to launch the Challenger was made solely by the appropriate NASA officials without any outside intervention or pressure.

Other Safety Considerations

In the course of its investigation, the Commission became aware of a number of matters that played no part in the mission 51-L accident but nonetheless hold a potential for safety problems in the future.

Some of these matters, those involving operational concerns, were brought directly to the Commission's attention by the NASA astronaut office. They were the subject of a special hearing.

Other areas of concern came to light as the Commission pursued various lines of investigation in its attempt to isolate the cause of the accident. These inquiries examined such aspects as the development and operation of each of the elements of the Space Shuttle - the Orbiter, its main engines and the External Tank; the procedures employed in the processing and assembly of 51-L, and launch damage.

The Commission examined potential risks in two general areas. The first embraced critical aspects of a Shuttle flight; for example, considerations related to a possible premature mission termination during the ascent phase and the risk factors connected with the demanding approach and landing phase. The other focused on testing, processing and assembling the various elements of the Shuttle.

Ascent: A Critical Phase. The events of flight 51-L dramatically illustrated the dangers of the first stage of a Space Shuttle ascent. The accident also focused attention on the issues of Orbiter abort capabilities and crew escape. Of particular concern to the Commission were the current abort capabilities, options to improve those capabilities, options for crew escape and the performance of the range safety system.

It was not the Commission's intent to second-guess the Space Shuttle design or try to depict escape provisions that might have saved the 51-L crew. In fact, the events that led to destruction of the Challenger progressed very rapidly and without warning. Under those circumstances, the Commission believes it is highly unlikely that any of the systems discussed, or any combination of those systems, would have saved the Challenger crew.

The Space Shuttle System was not designed to survive a failure of the Solid Rocket Boosters. There are no corrective actions that can be taken if the boosters do not operate properly after ignition; i.e., there is no ability to separate an Orbiter safely from thrusting boosters and no ability for the crew to escape the vehicle during first-stage ascent. Neither the Mission Control Team nor the 51-L crew had any warning of impending disaster. Even if there had been warning, there were no actions available to the crew or the Mission Control Team to avert the disaster. Nevertheless, the Commission did conclude that other escape systems and abort options should receive intensive review and made specific recommendations in this regard.

Landing: Another Critical Phase. The consequences of faulty performance in any dynamic and demanding flight environment can be catastrophic. The Commission was concerned that an insufficient safety margin may have existed in areas other than Shuttle ascent. Entry and landing of the Shuttle are dynamic and demanding with all the risks and complications inherent in flying a heavyweight glider with a very steep glide path. Since the Shuttle crew cannot divert to any alternate landing site after entry, the landing decision must be both timely and accurate. In addition, the landing gear, which includes wheels, tires and brakes, must function properly.

These considerations were examined by the Commission for both normal and abort landings. It found that although there are valid programmatic reasons to land routinely at Kennedy, there are concerns that suggest that this is not wise under the present circumstances. For example, the realities of weather cannot be ignored. With the capabilities of the system today, the Shuttle cannot afford to operate outside its experience in the areas of tires, brakes, and weather. Pending a clear understanding of all landing and deceleration systems, and a resolution of the problems encountered to date in Shuttle landings, the most conservative course must be followed in order to minimize risk during this dynamic phase of flight.

The Commission, therefore, made specific recommendations to restrict Shuttle landings and improve Shuttle landing systems.

Shuttle Elements. The Space Shuttle Main Engine teams at Marshall and Rocketdyne have developed engines that have achieved their performance goals and have performed extremely well. Nevertheless, the main engines continue to be highly complex and critical components of the Shuttle that involve an element of risk principally because important components degrade more rapidly with flight use than anticipated. Both NASA and Rocketdyne have taken steps to contain that risk. An important aspect of the main engine program has been the extensive "hot fire" ground test program. Unfortunately, the vitality of the test program has been reduced because of budgetary constraints. The number of engine test firings per month has decreased over the past two years. Yet this test program has not yet demonstrated the limits of engine operation parameters or included tests over the full operating envelope to show full engine capability. In addition, tests have not yet been deliberately conducted to the point of failure to determine actual engine operating margins.

The Orbiter has also performed well. There is, however, one serious potential failure mode related to the disconnect valves between the Orbiter and the External Tank. The present design includes two 17-inch diameter valves, one controlling the oxygen flow, and the other the hydrogen flow from the tank to the Orbiter's three engines. An inadvertent closure during normal engine operation would cause a catastrophe due to rupture of the supply line and/or tank. New designs are under study, incorporating modifications to prevent inadvertant valve closures. Redesigned valves could be qualified, certified and available for use on the Shuttle's next flight.

Processing and Assembly. During the processing and assembly of the elements of flight 51-L, various problems were seen in the Commission's review which could bear on the safety of future flights.

During the 51-L processing, waivers were granted on 60 of 146 required Orbiter structural inspections. Seven of these waivers were second-time waivers of inspections.

Furthermore, throughout the Commission's review of the accident, a large number of errors were noted in the paperwork for the Space Shuttle Main Engine/Main Propulsion System and for the Orbiter. The review showed, however, that in the vast majority of cases the problem lay in the documentation itself and not in the work that was actually accomplished. The review led the Commission to conclude that the Operations and Maintenance Instructions are in need of an overall review and update, and the implementation of Operations and Maintenance Instructions needs to be improved.

At the time of launch, all items called for by the Operational Maintenance Requirements and Specifications Document were to have been met, waived or excepted. The 51-L audit review revealed areas where such requirements were not met and were not formally waived or excepted.

Another aspect of the processing activities that warrants particular attention is the Shuttle Processing Contractor's policy of using "designated verifiers" to supplement the NASA quality assurance force. Due to reduced manpower, NASA quality assurance personnel now inspect only areas that are considered more critical. Thus the system of independent checks that NASA maintained through several programs is declining in effectiveness. The effect of this change requires careful evaluation by NASA.

Finally, technicians interviewed by Commission investigators said that accidental damage is not consistently reported, when it occurs, because of lack of confidence in management's forgiveness policy and the technicians' consequent fear of losing their jobs. This situation has obvious severe implications if left uncorrected.

Development Nature of Program. The Space Shuttle program, like its predecessors Mercury, Gemini, Apollo, Skylab and Apollo-Soyuz, is clearly a developmental program and must be treated as such by NASA. Indeed, the chief differences between the Shuttle and previous developmental programs are that the Shuttle is principally a transportation system and employs reusable hardware. Reusability implies a new set of functions such as logistics support, maintenance, refurbishment, component lifetime evaluation and structural inspections that must be accomplished by the program.

In order to enhance post-flight "turnaround" schedule and efficiency, NASA is striving to implement processing procedures accepted by the transportation industry. While this effort is useful, there is not an exact industry analogy to the Orbiter vehicles' flight operations, because each successive Shuttle mission expands system and performance requirements. Consequently, the Shuttle configuration is evolving as design changes and improvements are incorporated. These developmental aspects make significant demands, which can be met only by the following strategies:

-- Maintain a significant engineering design and development capability among the Shuttle contractors and an ongoing engineering capability within NASA.

-- Maintain an active analytical capability so that the evolving capabilities of the Shuttle can be matched to the demands on the Shuttle.

In short, the Shuttle's developmental status demands that both NASA and all its contractors maintain a high level of in-house experience and technical ability.

Recommendations

The Commission conducted an extensive investigation of the Challenger accident to determine the probable cause and necessary corrective actions. Based on the findings and determinations of its investigation, the Commission unanimously adopted recommendations to help assure the return to safe flight.

Recommendation One

Design. The faulty Solid Rocket Motor joint and seal must be changed. This could be a new design eliminating the joint or a redesign of the current joint and seal. The Commission established specific criteria for evaluation, certification and testing of the new design.

Independent Oversight. The Administrator of NASA should request the National Research Council to form an independent Solid Rocket Motor design oversight committee to implement the Commission's design recommendations and oversee the design effort.

Recommendation Two

Shuttle Management Structure. The Shuttle Program Structure should be reviewed. A redefinition of the Program Manager's responsibility is essential. This redefinition should give the Program Manager the requisite authority for all ongoing STS operations. Program funding and all Shuttle Program work at the centers should be placed clearly under the Program Manager's authority.

Astronauts in Management. The Commission observed that there appears to be a departure from the philosophy of the 1960s and 1970s relating to the use of astronauts in management positions. These individuals brought to their positions flight experience and a keen appreciation of operations and flight safety. NASA should encourage the transition of qualified astronauts into agency management positions. The function of the Flight Crew Operations Director should be elevated in the NASA organization structure.

Shuttle Safety Panel. NASA should establish an STS Safety Advisory Panel reporting to the STS Program Manager. The charter of this panel should include Shuttle operational issues, launch commit criteria, flight rules, flight readiness and risk management. The panel should include representation from the safety organization, mission operations, and the astronaut office.

Recommendation Three

Criticality Review and Hazard Analysis. NASA and the primary Shuttle contractors should review all Criticality 1, 1R, 2, and 2R items and hazard analyses. This review should identify those items that must be improved prior to flight to ensure mission success and flight safety. An Audit Panel, appointed by the National Research Council, should verify the adequacy of the effort and report directly to the Administrator of NASA.

Recommendation Four

Safety Organization. NASA should establish an Office of Safety, Reliability and Quality Assurance to be headed by an Associate Administrator, reporting directly to the NASA Administrator. The office should be assigned the work force to ensure adequate oversight of its functions and should be independent of other NASA functional and program responsibilities.

Recommendation Five

Improved Communications. The Commission found that Marshall Space Flight Center project managers, because of a tendency at Marshall to management isolation, failed to provide full and timely information bearing on the safety of flight 51-L to other vital elements of Shuttle program management. NASA should take energetic steps to eliminate this tendency whether by changes of personnel, organization, indoctrination or all three.

In addition, a policy should be developed which governs the imposition and removal of Shuttle launch constraints. Flight Readiness Reviews and Mission Management Team meetings should be recorded. The flight crew commander, or a designated representative, should attend the Flight Readiness Review, participate in acceptance of the vehicle for flight, and certify that the crew is properly prepared for flight.

Recommendation Six.

Landing Safety. NASA must take actions to improve landing safety. The tire, brake and nosewheel steering systems must be improved. The specific conditions under which planned landings at Kennedy would be acceptable should be determined. During unpredicable weather periods at Kennedy, program officials should plan on Edwards landings.

Recommendation Seven

Launch Abort and Crew Escape. The Commission recommends that NASA:

-- Make all efforts to provide a crew escape system for use during controlled gliding flight.

-- Make every effort to increase the range of flight conditions under which an emergency runway landing can be successfully conducted in the event that two or three main engines fail early in ascent.

Recommendation Eight

Flight Rate. The nation's reliance on the Shuttle as its principal space launch capability created a relentless pressure on NASA to increase the flight rate. Such reliance on a single launch capability should be avoided in the future.

NASA must establish a flight rate that is consistent with its resources. A firm payload assignment policy should be established to include rigorous controls on cargo manifest changes.

Recommendation Nine

Maintenance Safeguards. Installation, test, and maintenance procedures must be especially rigorous for Space Shuttle items designated Criticality 1. NASA should establish a system of analyzing and reporting performance trends of such items. NASA should restore and support the Orbiter maintenance and spare parts programs and stop the practice of removing parts from one Orbiter to supply another.

Concluding Thought

The Commission closed its report with the following concluding thought which I believe is a fitting way, Mr. Chairman, to conclude the testimony:

> The Commission urges that NASA continue to receive the support of the Administration and the nation. The agency constitutes a national resource that plays a critical role in space exploration and development. It also provides a symbol of national pride and technological leadership. The Commission applauds NASA's spectacular achievements of the past and anticipates impressive achievements to come. The findings and recommendations presented in this report are intended to contribute to the future NASA successes that the nation both expects and requires as the 21st century approaches.

Thank you very much, Mr. Chairman. I will be glad, along with the Commission Vice Chairman, Neil Armstrong, to answer any questions you may have.

Mr. ROGERS. I also want to point out a little bit about the scope of our investigation because I know one of the things the committee will be interested in is the scope of it. It was a very intensive investigation. It lasted really 3 months. The last month was pretty much involved in preparing the report because we had to get the report to the printer about 2 weeks before it could be published. So after we had hearings for about 2 months—pardon me; you can see we've had a long investigation. So we spent the last month preparing a report and getting it to the printer.

And I point out here that we had about 70 witnesses who testified. There are about 2,800 pages of testimony, about 160 individuals we interviewed. There were 46 Commission panel sessions that were conducted. I point that out because we broke up into panels. We had four panels. Each of the panels conducted their own private investigation—or maybe private isn't the word—investigation on special aspects of the investigation.

We have about—there were 6,800 reports of documents we reviewed, totaling more than 122,000 pages. Thirty-three NASA task force reports were prepared in part in cooperation with the Commission panel members and were submitted to the Commission for review and analysis.

So the investigation is a very comprehensive investigation, and all the information will be available to this committee. It will be automated, and you can retrieve any aspect of it as you want. We'll make it completely available to the staff of the committee.

We have provision made so all the material will be at the Archives, and you will be able to get any part of the work of the Commission that you want to.

I think you will find, Mr. Chairman, that it may be the most complete and thorough investigation of its kind that's been done, and I want to take this opportunity to say that the members of the Commission really were amazing in the dedication and hard work that was involved.

I also want to pay particular tribute to Dr. Keel and his staff, who did really a marvelous job. I'm sure that if you've had a chance to look at this report, you will realize how thorough it is. How we were able to turn it out, I don't know. I sure couldn't have done it except with people like Dr. Keel. I enjoy all the credit I'm getting, but I didn't have much to do with it.

Well, I thought the best thing to do, Mr. Chairman, in the interest of time, is to merely go to the questions.

Let me say that I think everything that we can think of that we could properly say is in this report. I don't have anything else to say.

In fact, if I don't get my voice back, I won't say it. [Laughter.]

I think the report is a very thorough one, and it was written deliberately with the idea that you can't read any one part of it and get an answer. You have to read all the report. And I think the impact of it comes from the total reading of it.

There's no doubt about it that serious mistakes were made. There were failures. We set them all out. You may find others that we haven't discovered, but I doubt it. I doubt that you'll find very much that is not covered by the report.

And I think that the problem that the Nation faces, in part your committee faces, is, What do we do from now on? Where do we go from here? And we were not asked to deal with that subject. That's really a subject for this committee.

And with that, I'll go to questions.

Mr. ROE. Is there any further comments to be made by Mr. Armstrong at all?

Mr. ARMSTRONG. No, sir; I would just like to make one correction. I would just like to——

Mr. ROE. You have to pull that closer [referring to microphone]. It's hard to hear.

Mr. ARMSTRONG [continuing]. Make one correction to the chairman's comments. Contrary to what he said, he had a great deal to do with the report, and no one on the Commission worked longer or harder, and you'll see his impact on every page.

Mr. ROE. We appreciate that comment.

Now let's proceed from there. What we're going to do is give the members an opportunity—and realize we're not going to be able to complete today—to propound any questions or observations they may have, and then we'll go from side to side so those points can be brought forward.

And I would just like to open up with two short comments and any suggestions or response you may wish to make.

I have had the opportunity—last night, if I look a little sleepy, I read the whole report from cover to cover. And I think you're totally right, Mr. Secretary, when you say that the report has to be read in context. I think that's true, and it comes more clearly to the point as to the issues involved.

Again I think from the members' point of view, there's many issues that the Commission has raised in their report and some that have deliberately been left, what would you say, not complete, so to speak, and that's left to the committee to decide what they want to do in the future on that.

But the thought occurred to me in two directions in your observations or review: really how safe is the shuttle? When you read the section particularly with the failure and the history behind the failure of the O-ring area, it does bring into point the safety critical items list and the number of items on that list. And I wonder if you've had a chance to evaluate leaving out the accident cause vis the O-ring issue and the other peripheral matters relating thereto—how safe is the shuttle in your judgment, considering I believe there's close to 2,000 items that are listed on the critical items list, as I recall?

Mr. ARMSTRONG. Mr. Chairman, we did not complete a total evaluation of the shuttle, nor was it our mandate, nor would it have been possible in the 4 months we had available.

We concentrated on what was the cause of the accident, but in the pursuit of those—that cause or causes certain additional items did come to our attention which the Commission was persuaded were of substantial interest from a safety perspective, and to the extent we were able to, through our panel work and through NASA teams, investigate those areas as they came to our attention, we did so.

Each of the things in that arena that we felt to be significant and felt needed additional work we tried to identify, with helpful suggestions, as to how that might be done without infringing on the responsibilities of the agency.

We, as a commission, are not in a position to be able to assure you or anyone that all the areas of the shuttle are safe. We can say that certainly the solid rocket booster needed attention, and we spelled that out in a good deal of detail in the report, and several other areas.

At the same time, I think we can say that we found a lot of work was exceptionally well done. We found outstanding design, processing, and execution within the shuttle itself. So we do not in any way imply that everything needs a careful examination.

Mr. ROE. Would it be a fair commentary to say, though, that one of the key items of safety is the key issue, one of the key issues we're speaking to, that certainly where the safety critical items list is involved, that that ought to have a total re-review from top to bottom by NASA? Would that be a fair—in process, in management, quality control, cost evaluation, cost relating thereto? Is that a fair comment?

Mr. ARMSTRONG. Yes, Mr. Chairman; we have specified that we recommend that review be done, and it's our understanding that Admiral Kruly is in the process of conduting such an evaluation at this time.

Mr. ROE. I appreciate that.

One other short——

Mr. ROGERS. Mr. Chairman, can I say, on— recommendation No. 3 covers that, and I would just like to add to what Neil said that we recognize that there's never complete safety to be assured in the shuttle system, but I think in answer to your basic question, yes, I think it's possible to continue the program safely, with reasonable safety. And I think that if the recommendations of the commission are followed that we can do that as a Nation.

Mr. ROE. I agree with you.

Let me just ask one other quick question. One of the questions you have risen in your report was the process and the thought process in reference to emergency escape system or a crew bailout. You didn't get into too much depth on that. Could you elucidate further to the committee what your observations were?

Mr. ROGERS. Well, I think this would be more appropriate for Mr. Armstrong to answer.

Mr. ROE. Mr. Armstrong.

Mr. ARMSTRONG. Mr. Chairman, studies in the area of crew escape have been conducted by NASA since the instigation of the shuttle program. For various reasons that are detailed to some degree in the report, those systems were not implemented.

We're persuaded that a complete crew—all situation crew escape system is not practical nor desirable, but we do think that limited escape possibilities might be providable and should be investigated.

Mr. ROE. So you're saying fundamentally it should be re-evaluated?

Mr. ARMSTRONG. Yes, sir.

Mr. ROE. Is that fair?

The Chair recognizes the distinguished gentleman from Florida, Mr. Chairman.

Mr. FUQUA. I'll defer at the present time, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished minority leader, Mr. Lujan, from New Mexico.

Mr. LUJAN. Thank you very much, Mr. Chairman.

And I want to again say that I'm very impressed with the report. I think the Commission did an excellent job, and of course one of the things that I look forward to, and the full committee looks forward to, is the other reports that we get that go more into detail, because my concern is what you spoke of just a few minutes ago, Mr. Secretary—where do we go from here? And that's our responsibility.

In that regard, I'm looking forward to further details. And I wonder if they might appear in those reports that we'll get further.

What I'm referring to is on the section entitled "An Accident Rooted in History." There are a number of generalities that say the joint test and certification program was inadequate. "Neither NASA nor Thiokol fully understood the mechanism by which the joint sealing action took place."

Everything worked because they got away with it, and they continued to do it, and on and on and on.

"The O-ring erosion history presented to level I at NASA headquarters in August 1985 was sufficiently detailed to require corrective action prior to the flight."

Now, I understand your reasoning that it wasn't your mission, but you have been quoted as saying, "Well, we didn't want to point any fingers." And I suppose none of us wants to get into that sort of thing.

But as a function of our oversight, we need to know what positions to zero in on to change the way that things were done, and in that respect we do need to know who was responsible or at least what position was responsible for not changing the design, for not getting on Thiokol for not doing testing that they were supposed to do, for failing to make the change testing upright rather than sideways, those kinds of things.

Will those things be in your followup report or is there anything that you could add to it at this point?

Mr. ROGERS. Well, first let me address the question about our jurisdiction. We felt that we were not required, nor should we, to make any judgments about who was responsible individually for what happened. In other words, our job was to find out the cause of the accident, make recommendations about future safety. Now in that process a lot of information developed as to individuals. A lot of it is cited in the report. So the committee will have available a lot of information about particular individuals, many of whom have been transferred already.

You will also find in our records that we have all of the answers, I believe, to the questions you want. We have very detailed information which will be in our appendix that were submitted by NASA about who attended meetings, and so forth.

But I think you'll probably not find that any one individual was responsible or any group of individuals. It was sort of a systems failure. Maybe some individuals were more responsible than others, but I don't believe it's going to be the type of thing that a grand jury would look into. And I think we've attempted to say in our report all of the things that we think will give this committee and the American people a way of judging what happened.

It was a system failure. And when you look at the report, you ask yourself, How could it have happened? I notice several comments by Members of Congress who read this over. They say they just don't understand how it happened, and we don't either for sure.

But I guess our job now, as I see it, is to get on with the work of how do we make it work in the future. Obviously there are lessons to be learned. We're not talking about that, but I'm not sure assessment of blame is going to be that beneficial to the future program.

I think the new Administrator of the program has that responsibility. He has to decide what management changes he wants and how he wants to deal with people that may have not performed up to their full responsibility. But I'm not sure that it does the Nation any good to undertake that—to try to answer that question.

What is going to be difficult for the Congress and for the administration, and for everybody, is: Where do we go from here? How do we correct it?

And I must say that Jim Fletcher's got a tough job, and I think he deserves the support of all of us. And these are difficult questions to answer in the future. And it's the responsibility of all of us.

Fortunately, we're—after today, I hope, or tomorrow we can step back into private life, but the problem is going to be with this committee and with the Congress and with Jim Fletcher and the administration.

I hope I haven't talked too long, but——

Mr. LUJAN. No; that's fine. I had one other—one question of Mr. Armstrong because he's had all kinds of experience through NASA—of course in the Apollo Program and you were a member of the President's Commission that Tom Paine had, plus this Commission. You've just been through the whole thing.

And we read sometimes that it's a different NASA today than it was perhaps in the Apollo days where safety was the prime consideration then. In other words, prove to me that it's unsafe would be what some people say is today the method of operation of NASA. Do you find a difference between now and then—then and now?

Mr. ARMSTRONG. Yes, sir, I do find some differences, but it's difficult to quantify what the effects of those differences might be, aside from the fact that we are involved in this particular investigation.

I suppose, at the risk of oversimplifying, in the Apollo days we always expected everything would go wrong and were surprised when it didn't, and in the current situation, at least the American public expects the shuttle to fly right and is surprised when it doesn't.

Mr. ROE. The Chair recognizes the distinguished gentleman from New York, Mr. Scheuer.

Mr. SCHEUER. Thank you, Mr. Chairman.

Mr. Rogers and Mr. Armstrong, we're very grateful for the time and the expertise and the real character definition that you've given this report. You've rendered a great, great service to the American people.

And nobody up here wants to continue trashing NASA in any purposeless way, but there are some difficult questions that we have to answer. And one difficult question is this whole attitude, this whole new culture that grew up in NASA and perhaps in the Marshall Center, this culture that's been called arrogance, conceit that they knew it all; they didn't need to include in the information circle outside experts. They didn't need to listen to the Rockwell fears, expressed fears of the subzero temperatures. They pressured Morton Thiokol not to bother with a lot of chintzy concerns about safety. They excluded the astronauts themselves from the information circle. They had the feeling that they knew it all and didn't need any outside information. They didn't want anything to interfere with the schedule. The schedule seems to be the thing and not the safety and efficacy of the mission.

How do you change this? This is the job that you're directed us to solve, that you've given so much energy and emotion and intellect to. It's hard to sum up in a thumbnail sketch. How do you change that attitude? How do you institutionalize better information circles? How do you institutionalize access by all of these experts to very tough decisionmaking channels, if they had deeply seated concerns about safety, even in the last moments before the takeoff? And how do you legislate humility? How do you legislate openness? How do you legislate concern for safety?

These are tough questions for legislators. It's not susceptible to legislation, but we've got to get back to that old "can do" spirit where there was a team and safety and efficacy of the mission was No. 1; and that they wouldn't have dreamed of being—in the early years of being pressured by anybody, not that there's any evidence that I can see of pressure, unless it was self-imposed pressure.

How do we get back to the original driving commitment that safety to success with individual egos taking a second place and a whole new openness of attitudes?

Mr. ROGERS. I think you've put your finger on a key question the Commission talked a good deal about. I hope that that will be accomplished, in part by the report and in part by the investigation, in part by the fact that all of this became public.

And I—to illustrate your point, after we had the hearings which disclosed the opposition of the launch and the failure to communicate that to those people who made the decision to launch, we were all—I don't know whether shocked is too strong a word or not, but we were very concerned about that as a commission. And right at that time the people in Marshall who were involved had a press conference at which they sort of took issue with us, that we were making too much out of it, which to me illustrated the points you're making.

I mean, they have to vastly change this mindset. You can't go on this way as if nothing happened. This was a major, major mistake, a tragic accident, and it was witnessed by everybody in the world either at the time or subsequently on television. So there has to be a change of attitude.

And I'm not sure how it can be—we have the same problem you do, but I think it will be done by—first, by the fact that we've had this investigation. We didn't pull any punches. All of the facts were laid out on the table, and we think that that will in itself be very salutary.

Second, it will be required of the leadership of NASA. You've got Jim Fletcher, a new Administrator. You have Admiral Truly that worked very well and hard with the Commission and I think will do an excellent job in that capacity in charge of the shuttle program. He himself is an astronaut. And he is just as concerned as all of us are about what happened.

In fact, he told us yesterday, which I think illustrates the point, that he flew on the second shuttle flight, STS-2, and on that flight they had difficulty with this joint. And he didn't know it, and he didn't know it until after this accident. And you know what kind of an effect that will have on his thinking, and his attitude toward what happened is just the same as the Commission's attitude. And I think that will be reflected in the whole program, and certainly that's what we hope.

Nobody could be sure that everything is going to be safely done. Everybody should know about the risks involved. If you're proceeding with a joint that isn't going to work, everybody should know it. You should say, "We're all going to take a chance on this joint not working." That may be necessary.

The problem here was people didn't know about it. If you read the report, you see the key people in the program didn't really know about the joint or didn't know about the seriousness of the problem. And I hope that the result of this investigation will be to correct that.

Mr. ROE. The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Chairman Rogers, at any time was the Commission pressured by anyone not to fully report on the problems it discovered?

Mr. ROGERS. No, nobody—we had no discussion with anybody about that at all. In fact, we didn't have any discussions with anybody outside that I know of about anything, except the work that we were doing. We were moving so fast we hardly were able to take phone calls.

Mr. WALKER. So, in other words, the report as you published it represents your best thinking on what went wrong on everything that went wrong?

Mr. ROGERS. Yes; absolutely.

Mr. WALKER. With all—I spent some time going through the report last night, and I congratulate you. I think it really is a job well done. But with all of this going wrong, did you get any hint of why Congress wouldn't have seen at least some of these problems at some point before we had a tragedy?

Mr. ROGERS. No, I didn't. I'm not sure I would have answered if I did, but we didn't see any. [Laughter.]

We didn't see anything like that, Congressman.

Mr. WALKER. Well, but doesn't it strike you that in the oversight process that some of the problems that are revealed here should have in some way come out prior to having a tragedy?

Mr. ROGERS. Well, I said yesterday that—at the press conference we had after the ceremony that I think everybody's in part to blame. I mean I think the administration, several administrations, took it for granted everything was working well. I think Congress probably thought the same thing and maybe didn't perform their oversight functions as well as they should. The press is in part responsible. I heard Mr. Hotz, one of the members of the Commission, on television this morning saying he was then the editor of Aviation Week, and he said he thought the press was in part responsible. I guess the American people themselves were in part responsible. We were all too optimistic about it.

And, as I say, I don't know if it serves any purpose to point fingers. I think Congress has to share the blame in part; so do the rest of us.

Mr. WALKER. I think that's a reasonable way of looking at it, but I guess my concern is that, as someone who has sat and listened to testimony over the years, a lot of these things were happening, they were knowingly happening, and nobody was mentioning it. Now is there anything that in your opinion was being done that was kind of a longstanding systematic coverup of some of these problems?

Mr. ROGERS. No, I didn't see anything like that.

Mr. WALKER. Well, then, how can we—how is it that we can be developing basically systematic problems, problems of management that are systemic, and yet nobody have a hint that a lot of these things were going wrong?

I mean, are we in a position in the space program where we are only going to be able to react to crisis?

Mr. ROGERS. No, I don't think so. I think that we have to keep in mind that we had 24 successful flights, and we were the most successful nation in the world in what we've done. So we can't just look at the dark clouds. There were a lot of successes.

Look at Neil Armstrong—a lot of successes, and we can't forget that. And we don't want to blame our Nation or ourselves too much. On the other hand, we don't want to overlook the seriousness of this problem.

I hope that our commission work will have accomplished that purpose. I hope that it's balanced enough so that it takes into account the successes of NASA and successes of our Nation and at the same time points the way for future progress in space.

Mr. WALKER. Well, at least one of the commissioners was reported this morning as stating that, if the *Challenger* accident hadn't happened, the program would be shut down now anyhow because that the resources are not compatible with the flight rates, and so, therefore, there would not have been enough spare parts availability; there would not have been enough resources available to keep the program flying.

Now obviously problems of that kind of a systemic nature didn't just develop overnight, and that has nothing to do with the public perception of the program. It has a lot to do with OMB. It has a lot to do with the Congress.

And I guess my concern is, after reading all of this, it seems to me that there was a fairly significant failure in the people who were providing policy direction to NASA, because I gather in the report NASA was doing a pretty good job of following the policies dictated to it; is that not true?

Mr. ROGERS. Well, as I say, I don't really want to get into the business of whether Congress was to blame or the administration was to blame or NASA was to blame. It's all there. When you read it, you can form your own conclusions.

I think Congress bears some of the responsibility. I think you will do a better job in the future. I think your oversight responsibility is great. It's going to be greater in the future, but I hope it's not negative. I hope it's all positive. We have to have the program. We need to have men in space. We don't need maybe such an optimistic program. We need some more ELV's, but we have to weigh very carefully what part of the program is going to involve humans and what part need not involve humans, but those are problems you have to decide, and they're not easy.

And I think we've laid out the problems that have occurred, what happened, and now it's up to Congress and the administration to try to deal with it.

Mr. ROE. The Chair recognizes the distinguished lady from Tennessee, Mrs. Lloyd.

Mrs. LLOYD. Thank you very much, Mr. Chairman.

I'm certainly glad to have you distinguished gentlemen with us, and we thank you for your time and all of your efforts on behalf of this country.

The *Challenger* accident, of course, is a real modern tragedy, and I'm reminded of the timeless dramatic tragedy MacBeth. Remember the humbling lines, "An eagle towering in its pride of place was a mousy owl popped at and killed."

It seemed to me that this modern tragedy of NASA, which is always the eagle to this committee, has not been killed, but it's certainly been wounded by pride, and our legendary high technology agency has become arrogant and careless.

Now I worry that public reaction could permanently cripple this eagle unless we do act constructively. And as members of this committee, we always believed that this bird would always soar and alight again unharmed. We want to know how you think that this committee could best aid in this process—to heal the wounded eagle. What do you think this committee can best do to aid the process of getting NASA to fly again, Mr. Chairman?

Mr. ROGERS. Well, that's a pretty tough question. I don't know as I have any advice. I think that the new administrator has a tough job, and I think Admiral Truly is very experienced, an astronaut himself, highly regarded by all the astronaut community and by, in particular, NASA, and will do an excellent job.

And I think that probably the function that this committee can perform is to pay a lot of attention, to be thoughtful about the problems of the future, try to determine the extent of financial support that is required and how it best can be used, to be sure that there is a reinvigoration of NASA; that there is a method that is devised to attract some of the leading engineers, the younger engineers.

I think to get back—it's going to be difficult to get back and have the same inspirational drive that NASA had to begin with because this has been a very traumatic experience for NASA, and in a way it may be that our Commission's work is going to make it tougher.

Mrs. LLOYD. Mr. Secretary, would you——

Mr. ROGERS [continuing]. But I hope not. I hope that what we've done will make it better, and I hope it will—everybody will say, "We made a bad mistake. We've got to correct it, and let's get on with the job." And I think this committee, if it supports NASA in that respect, will perform a real public service.

Mrs. LLOYD. Mr. Secretary, other members have alluded to the fact that maybe Congress didn't really assume the proper oversight role, maybe we were a little neglectful in really evaluating the programs of NASA. Would you recommend, or you, Mr. Armstrong, that we assume a larger oversight role; that we try to micromanage, or would you prefer that we try to back off and leave NASA some room to really bring in new procedures in the oversight? Would you comment on that, Mr. Armstrong

Mr. ARMSTRONG. I'm not certain I'm prepared to give a well-reasoned answer to that, but just let me say—and it will also bear on Mr. Walker's question—that there's some evidence to indicate there was an imbalance between the goals and resources over a fairly long period of time, starting in the early seventies through the late seventies and into the early eighties. And the agency was trying to do amazing things, and did, and were pressed to do it with less resources in terms of people and financing, and so on. And they tried very hard to make—and did a remarkable job of making a remarkable machine with probably less technical insurance than they should have paid the premiums on.

Mrs. LLOYD. We've also alluded to the similarities of Apollo V two decades ago. Would you gentlemen like to comment on the similarities of these, of the two tragedies?

Mr. ROGERS. Here, again, I think Mr. Armstrong should answer that.

Mrs. LLOYD. Mr. Armstrong.

Mr. ARMSTRONG. I think many members of this committee were struck with the similarities, probably some differences, too, but similarities in that there were typical inadequacies that eventually caught up with the program and paid a severe price in time schedule and prestiges at the time, but Americans did what they do best—they stepped up to that kind of a problem and fixed it. I certainly hope, I believe, we can do it again.

Mrs. LLOYD. Again, I thank you distinguished gentlemen. Thank you.

Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Wisconsin, Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you, Mr. Chairman.

Mr. Secretary, I, too, would like to add my commendation to you and the other members of the commission for approaching this task with objectivity and calling them as you saw them. And I believe that the country is much in your debt as a result of the efforts that you made.

I hope that this set of hearings is used to put to rest all of the unanswered questions about the space shuttle disaster because I believe that the Nation and the space program can ill afford to have people second guessing the work of your Commission like we've seen second-guessing of the work of the Warren Commission into the assassination of President Kennedy.

In line with that, I agree with the fact that you didn't make any inquiry into individual responsibility, but during the course of your investigation did you come up with any evidence that you believe should be referred to the Justice Department for an investigation into criminal neglience?

Mr. ROGERS. No, I did not.

Mr. SENSENBRENNER. It's my understanding that Morton Thiokol did not meet the required spec limits on the solid rocket motor. Did your investigation reach this conclusion and, if so, why didn't NASA require them to meet specs?

Mr. ARMSTRONG. I don't think the Commission made the judgment on review of that particular fact and passed—and made a finding, Congressman.

Mr. SENSENBRENNER. I've been given some information that the specs for the solid rocket motor indicated that it was supposed to be functional between 31 and 99 degrees Fahrenheit. The chronology that your Commission has published as a result of your investigation indicated that at least at the middle, the upper middle level management engineers at Thiokol, the initial determination was not to launch because it was so cold in Florida at the time when the shuttle and the orbiter were on the launch pad, and that that was reversed—that decision was reversed as the discussions went on, and there was a recommendation made by Morton Thiokol to launch the night before the tragedy occurred.

Given the fact that Morton Thiokol was supposed to have built the SRB's to be launched at above 31 degrees Fahrenheit and there was some reluctance that the O-rings would crack by some of the engineers out there, what conclusions did you reach relative to the management decisions at Morton Thiokol and how that got reversed, and whether the reversal was caused by a fear of them having to admit that they did not meet the specifications that were set forth by NASA when they constructed the SRB's?

Mr. ROGERS. Mr. Chairman, can you hear us? I gather you're having a little problem.

Mr. ROE. We're having difficulties. I guess it's just the microphones, but go ahead.

Mr. ROGERS. I don't believe that that was the conclusion——

Mr. ROE. Much better [referring to microphones].

Mr. ROGERS. The conclusion that the Commission reached was they changed their minds—is that better?

Mr. ROE. Yes, much better [referring to the microphones].

Mr. ROGERS [continuing]. They changed their minds because we think that they were trying to accommodate a major customer. We say that in the report. In other words, they originally recommended against the launch unless the temperature was 53 or above, and after long, off-the-record—I mean off-the-telecom conference, they decided to recommend in favor of the launch. That was the management group, and the management group—one of the managers told the engineer, the chief engineer who had been against the launch, he should change his hat, go down—he should take off his engineer's hat and put on his manager's hat, and so they changed their mind and they sent a telex saying, "Go ahead and launch." And the Commission concluded that was done because they wanted to accommodate their major customer.

Mr. SENSENBRENNER. But here Thiokol delivered the solid rocket boosters for NASA allegedly meeting specs that were supposed to be functional over 31 degees Fahrenheit, and there were folks within the Thiokol organization that said you shouldn't do it if the temperature was under 53 degrees Fahrenheit. And I think that this is a major gap relative to the management decisions of this major contractor for NASA. Our oversight can fix up NASA's management by review. I'm wondering whether we really can fix up the management review of a contractor like Thiokol.

Mr. ROGERS. Mr. Armstrong had a comment on my last answer.

Mr. SENSENBRENNER. Yes.

Mr. ARMSTRONG. I don't recall the details of all the specifications on the original contract, but it's quite clear that the motor was obliged to operate under specification at temperatures greater than 40 degrees Fahrenheit. That was a low temperature of the propellant and, indeed, the low temperature of the propellant in this case had a temperature substantially above 50.

I do not recall whether there were specific requirements for ambient temperature, but there were launch commit criteria under which the spacecraft was obliged to fly at temperatures above 31 degrees, as you specified.

It should have been the responsibility of any contractor, in my view, if their particular piece of equipment that they were providing was not able to perform within that launch criteria to so identify that fact so that it could be factored into the launch commit criteria. We did not find evidence that that had been done in this case.

Mr. ROGERS. Dr. Keel might have elaboration on that point.

Dr. KEEL. I think, Congressman, there has been a lot of confusion about the various temperature specifications for the boosters. Part of that was brought about by the testimony that conflicts with the actual documents. I think that just came about over a period of time where the—with references to temperatures and the certification requirements was loosely referenced, if you will.

The 31-to-99 degree temperature requirement that's actually in the contract specifications refer to a storage temperature requirement for the solid rocket boosters and their propellant. During the program there were people who referred to that as actual performance specification requirements, but that's not what the documents support.

Mr. ROE. The Chair recognizes the distinguished gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

I might say that my understanding—that the actual design specs for the solid rocket booster was to go down to a temperature of 25 degrees Fahrenheit and be operational. And, indeed, that part of the evidence that was delivered to you all from the NASA investigatory team found that Thiokol had never tested down to 25 degrees, and that when asked why, nobody knew the reason—not in Thiokol nor in NASA—why it, in fact, had not been tested down to that design specification. And, therefore, that's one of the things that we'll continue to look at as we try to backstop your report.

And, Mr. Chairman, you have done an admirable service to your country, and I appreciate it.

Let me ask Mr. Armstrong just a quick question here. One of your recommendations in the design recommendation is "Full consideration should be given to conducting static firings of the exact flight configuration in a vertical attitude."

Our best estimate is that if you were to design a vertical test stand and instrument it and then go and build it, that you'd be looking upwards of 2 years, maybe a little less than 2 years, particularly if you're going to fire in the vertical position as it sits on the launch pad because you've got to have plenty of room underneath for the flame to get out, so you've got to get the SRB at least 80 feet into the air. I suppose if you turn it the other way, nozzle up and fire it with the flame up, but if you get it exact configuration, as you have recommended here, you're looking at upwards of 2 years before you can actually go out and test fire it in that configuration.

Do you have any insight, Mr. Armstrong, with all your background as to what you intended with regard to that specific recommendation?

Mr. ARMSTRONG. Yes, Mr. Nelson. It has been brought to the attention of the commission that several built facilities be modifiable to handle this very large test firing.

In addition, proposals have been made by some, including those within the agency, that the vertical firing be done in free flight.

And we did not have the opportunity to test the possibility of devising such a test, but the desirability is certainly there and we thought we should identify it, and there are those who believe it can be done without building a new facility.

Mr. NELSON. All right. You didn't come to a conclusion that, in fact, we should. You're just saying consider that as one of the options as you try to get the reliability on the SRB?

Mr. ARMSTRONG. Yes, sir, all consideration should be given.

Mr. NELSON. OK. Mr. Chairman, I'll reserve the balance of my time.

Mr. ROE. I thank the gentleman.

The Chair recogizes the distinguished gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Mr. Secretary, at the outset I'd like to say that the commission which bears your name and has benefited from your enlightened leadership does our system proud. I can't think of any place in the world where a failure of a national program, an inquiry into that failure, would be as thorough and as public as this one is. So I want to thank you and your colleagues, first of all.

But, second, let me say that I'm a natural for this committee. I got a D in high school physics and haven't taken a science or technical course since. [Laughter.]

But the benefit of that is that I would ask of you the same questions that I think the people I'm privileged to represent would ask if they were given the opportunity. And I note in your report that section which refers to the silent safety program. My concern is that it's a near invisible safety program.

For example, I understand that NASA does not have a specifically labeled risk management program. Further, I understand that from 1970 to 1985 the quality assurance personnel dropped from a high of 1,689 in 1970 to 505 in 1985. And, further, when we're dealing with payload, I understand that while NASA audits the certification process, it does not perform any visual inspection of the payload for performance-to-safety standards.

It seems to me that with missions becoming a lot more complex, the risks are greater, we should have a dramatic increase in safety, and yet it seems to be moving in the other direction. Is that an area of particular concern, Mr. Secretary?

Mr. ROGERS. It is, and we address that in our report. As you see, we spent a lot of time on that, that subject. I think you're absolutely right—there has to be a lot more emphasis. And we recommended that a single person, an assistant to the administrator, be at headquarters with sole responsibility of safety—to devote himself directly and fully to that problem. And then we have set up—recommended some safety panels be set up which were consistent with the way the Apollo program used to work and consistent with the way the astronauts think it should work.

So you're absolutely right, and although some people point out that safety is the responsibility of everybody in the program, which is obviously correct, the fact is that in this case, whereas everybody said they were concerned about safety, they weren't going to fly unless everything was safe, the fact was it fell between the chairs. There was nobody that really was paying full attention to that subject.

And when people were briefed about the weakness of this joint, it was always in fine print or the footnotes, hardly noticeable. So we feel that you're absolutely right, and the thrust of our recommendation is that there has to be a lot more attention given to safety.

Mr. BOEHLERT. Mr. Secretary, did budget reductions have anything to do with the compromise on safety?

Mr. ROGERS. Well, I'm not sure I can answer that, but I would think so, yes.

Mr. BOEHLERT. Let me ask you another question. Did the commission have some difficulty in reconstructing some of the conversations that occurred between Morton Thiokol, for example, and the NASA people prior to the launch? Would one of your recommendations be that there be tapes of these conversations so that we can have for history a very accurate record?

Mr. ROGERS. Yes; that is one of our recommendations.

Mr. BOEHLERT. Let me ask something else of Mr. Armstrong, if I may. I think in your opening statement you made some reference somewhere along the line to crew escape. You said a bailout or an ejection system might not be practical or even desirable. Could you expand upon that?

Mr. ARMSTRONG. Yes, sir. What I—escape systems take a variety of forms from very simple jump-out-the-door to very complex systems in which an entire section of the vehicle is removed and ejected by rocket propulsion or some other means and recovered as a unit.

We think these more exotic systems are probably not practical to incorporate in this design at this stage, but the ones on the simple end deserve additional examination because as the system exists now for significant parts of the envelope there really is no method of survival, and we believe some additional method of survival is possible.

Mr. BOEHLERT. But am I correct in assuming that this whole thing occurred within 73 seconds, so that any escape mechanism, any ejection system that might be conceived by man wouldn't have been enough to save the crew?

Mr. ARMSTRONG. Yes, sir, you're quite correct. We do believe that none of the systems that we've looked at, to the extent we've been able to look at them, would have been able to save the crew in this circumstance.

Mr. BOEHLERT. Thank you.

Mr. ROE. The Chair recognizes the distinguished gentleman from North Carolina, Mr. Valentine.

Mr. VALENTINE. Yes, Mr. Chairman.

I want to say to you I hope that this committee does not with your committee get any kind of NASA problem. You know you have received a lot of flowers since you have come in here, and I'm sure we won't make that same mistake.

I want to say to you seriously that I want to congratulate you, sir, and other members of this committee not only for what you have done, but for living lives that would equip you to be selected to serve on this committee. I think it's a credit to our country and to each of you, because what you have said I think in the work of the committee is perhaps some of the most important work to be accomplished in the history of the Republic.

And I just would like to ask you mainly one question. You have been very complimentary in what you said about this committee, and I think it reflects on the leadership, the chairman, the ranking Republican member, the subcommittee chairmen, and so on.

Do you feel that you received complete cooperation from all of the people at NASA with whom you came into contact, you and other members of the committee, whom you interrogated, and do you feel that you received full and complete cooperation from the contractors and subcontractors?

Mr. ROGERS. If you don't mind, let me take just a moment to answer that because it does divide itself into two parts.

After a week or so when it appeared to the commission that the decisionmaking process was flawed and there were a lot of people in that decisionmaking process who might have in some way failed to perform properly, we asked that they be excluded from any part of the investigation. And at that point NASA put in charge of the investigation Admiral Richard Truly who is going to continue in his work at NASA, and they cooperated with the commission fully in every respect. They responded to every request. They volunteered information that sometimes was embarrassing, and that cooperation on the part of the investigative panels of NASA under his leadership could not have been better.

And that was true generally throughout NASA. And you will see from the work of these panels, which is very voluminous, that they did a hell of a good job.

Now as far as—there was one aspect of it that we were not satisfied with, and that was failure of the people at Marshall to tell us some facts about their constraints, launch constraints. That was not known to the Truly people, and the Marshall people gave an excuse why that had not been done, but we were not satisfied with that aspect about it. And I made some comments in the hearings about that, saying that they had almost been able to cover that up. Fortunately, we were able to find out that there had been launch constraints in five previous flights previous to 51-L, and that constraints had been removed without any particular reason, it appeared on the surface, and we were upset by the fact that the commission had not been advised of those constraints earlier on.

But as far as NASA as a whole is concerned, they cooperated fully, and they did one excellent job in all respects in giving us the information. And it's all available for your committee to look, and your subcommittee has worked very well with us. We've worked with your staff, and your staff will have access to all of our records. And Dr. Keel will be able to help your committee staff in that regard.

Mr. VALENTINE. Thank you, sir.

Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Florida, Mr. Lewis.

Mr. ROGERS. Dr. Keel—excuse me just a minute—Dr. Keel just pointed out I have not answered your question, Mr. Valentine about contractor cooperation.

I think that in Morton Thiokol's case they did cooperate fully with us in providing documents. They were very cooperative. We had a lot of people out there from time to time, and they did give us the documents and they volunteered.

Initially in the conference, Mr. Locke, who is the chief executive officer, had with Dr. Keel—that they would cooperate fully, and I think it's fair to them to say that they did provide all the information we wanted.

Mr. ROE. Mr. Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Secretary, let me also offer my words to thank you for the tremendous job you and your Commission have done in this tremendous report.

In the report the level III imposed a launch constraint on joints but waived that constraint. And the Commission recommendation is that a policy should be developed which governs the imposition and removal of launch constraints.

Now since the Marshall project manager, specifically Mr. Mulloy, which I'm reading in your report, the SRB manager, didn't feel inclined to communicate problems to the program manager, wouldn't the effect of requiring him to inform the program manager of a launch constraint, especially if this resulted in taking away the authority to remove that constraint, simply be for him not to impose a constraint in the first place?

Mr. ROGERS. Well, I'm not sure. I think the problem we have is that there seemed to be no criteria for—in the first instance in placing the constraint and no criteria for removing it. And what we have recommended is that they have a thorough review of that system, and if they have a constraint on a launch, then there should be a finding by a group or someone that they're going to launch anyway.

I mean, the idea of the constraint was don't launch until you fix it. "There's something wrong here, we find, and there's a constraint on this launch until something is done about it. It has to be corrected."

That appeared to be not the case. In other words, the man that put the constraints on just took it off, and the others in the system didn't even know about it. And, as you will see in the report, a lot of the key people in the system didn't even know there was a constraint on the launch, so the constraint was meaningless.

Now actually the constraint was a correct constraint. They shouldn't have launched until they fixed that joint.

Mr. LEWIS. That's the point, Mr. Secretary. It was clear that Mr. Mulloy really didn't think that he had a problem or a life-threatening problem with the—at this time, and he was the most qualified person, he felt, to make this decision on the SRB.

So could this be simply a poor engineering judgment? How would a change in the system affect that?

Mr. ROGERS. Well, I really don't want to zero-in on Mr. Mulloy especially. If he thought it wasn't life threatening, why did he have the constraint on in the first place? That's the whole point of the constraint—was there's something seriously wrong and it's got to be fixed before we fly.

Now if it's just placed on and then taken off willy-nilly, it's meaningless. It loses all significance. So what we recommend is the system has to provide, if there is a constraint, why did you put the constraint on, and then there has to be a judgment by the system why you take it off. Why do you risk the lives of the crew until something's been done to fix it?

So I think that NASA—I think that this report will have the result of being sure that the whole system knows about a constraint on a launch and it won't be taken off until it's either fixed or—I mean, you could imagine a situation where everybody says it's impossible to fix this; nonetheless, we have to fly; we have to take a chance, and we all know that we're taking a risk; let's go ahead anyway. Well, that's understandable.

What's not understandable is not having the knowledge that goes with it in having uninformed decisions made. Informed decisions are one thing, and everybody can accept that, I suppose, in a program that's dangerous. What you can't accept is to have ignorance be the controlling factor.

Mr. LEWIS. That's a good point, Mr. Secretary, and I think if the SRB's had run their quality test to full specifications as required, then a better judgment could have been made at that time, or the judgment wouldn't even have had to have been made; it would have been made on the quality test.

Let me ask you before my time runs out—I'd like to talk about level I and level II managers that didn't know of Thiokol's telephone calls the night before, and it had been suggested and known that Thiokol had concerns over the temperatures—my time is up. I'll come back and ask the question later. Thank you.

Mr. ROE. The Chair recognizes the distinguished gentleman from New Jersey, Mr. Torricelli.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Mr. Rogers, you offered the judgment previously and answered questions from the gentleman from Wisconsin—in your judgment criminal negligence has not occurred and that a prosecution would not be in order. That is certainly a judgment that I share—that in the national interest it would—it does not make any sense to proceed in seeking a case of criminal judgment.

I have to, however, inquire whether your conclusion and my hope is not somewhat at variance with elements of the report. The threshhold for criminal negligence in our country is not high. There has been a loss of life. It would appear on the facts that such a loss of life was not only possible but probable, given certain information; that that information by individuals in a position to halt the launch either was known or should have been known. Those are the elements of a criminal negligence case.

While I do share your hope and belief that such a case is not necessary or warranted, nevertheless, that is not a decision for us to make. I wonder if you could comment on those facts and the legal statements that I've made.

Mr. ROGERS. Yes, I'll be glad to. Well, first let me say that my answer was in response to a question, and I gave it individually. This was not a matter considered by the Commission.

Mr. TORRICELLI. Let me ask it on that basis to you, then, as well, individually given your own legal background as well as your chairmanship.

Mr. ROGERS. Well, as I say, I haven't spent a lot of time thinking about this, but I am satisfied that it would be unwise to proceed criminally. I don't believe there was any venality here.

And I don't really believe there was gross negligence. I think there was misunderstandings about what each person was responsible for.

In the case of NASA, it's such a big organization, so many people, that it has all the evils of a bureaucracy. Responsibility is pretty diffuse. In this case, the Marshall people felt that they had the right to make decisions because they were level III, that they had the right to make final decisions that dealt with this.

The others at level II did not think that was the case. They felt they should have been told about this. Mr. Aldrich so testified. He's head of level II, and his testimony was to the effect that we are responsible for improvements in all these aspects and we didn't know it and we should have been told, and that was the mistake of the system.

But in terms of criminal negligence, you can certainly say that the people at Marshall thought that they had the right to, what they call, close out this problem; they had the right to decide it, and they decided it.

And there were a lot of people involved in that decision. It wasn't just Mulloy, Mr. Mulloy. There were a lot of other people, too, as you will see from the record.

So I think it would be very difficult to prove the willfulness or even gross negligence that's required for a criminal prosecution. And, as you say, I don't think it would be in the national interest.

Mr. TORRICELLI. As a matter of policy, I agree with you. It just appeared to me that legally it might be an open question.

Mr. Rogers, the majority of the members of this committee have now cosponsored legislation to rebuild the orbiter. We did so, and it was introduced, in the belief as we followed your hearings that the basic shuttle technology was sound; that the accident was more of a failure of management than a limit on technology. And, therefore, the platform as a vehicle—our Nation's hope should at least in part continue to rest with the shuttle and we should proceed.

I'd like you to react to those conclusions since they were largely reached on the basis of things we were learning from your Commission—that those things that need to be repaired can be repaired, but that the basic technology remains sound and a good investment for the United States.

Mr. ROGERS. Well, I think we all agree with that, or at least I think the members of the Commission agree with that. And we've so stated—that we think that NASA deserves the support of the administration and the American people.

But I guess I should add that we did not deal specifically with the question of whether Congress should support a fourth orbiter or not.

Mr. TORRICELLI. Nor, Mr. Rogers, am I asking you to get to that question, but, rather, that the basic shuttle technology is sound. There are failures in the system, but they can be addressed and can be corrected. The United States can continue to rely on the shuttle technology. That's the only conclusion that I want to make certain that all members of the Commission are on accord.

Mr. ROGERS. I think that's correct. Certainly I feel that way, and I'm sure that Mr. Armstrong does.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

I would like to commend Attorney Rogers and former astronaut Armstrong and the whole team for one incredible report.

They say a picture speaks a thousand words, and I just turned to page 113, and I look at the system during the day of the launch and they've got icicles that are a foot long or more. They've got instrument boxes encased in ice.

Now I—you know, we're talking about the theory of a decision process, but it would seem to me that if this picture had ever been conveyed by those on the scene to other higher levels of management, in no way, shape, or form would a decision have been made to go ahead, given the O-ring problems, the temperature problems with the O-ring, the design specifications for the O-ring. It went down to 8 degrees that night, and they say the ambient temperature was in and around 30 or so that—at the time of the launch. It's very conceivable that the O-ring itself was well below the ambient temperature.

It's really hard to believe. I mean, it is almost outrageous, but I guess we go forward.

I'd like to ask some specific questions here. You've recommended many safety-related changes. You recommend institutional and organizational changes, changes on the equipment side—main engines, landing systems, joint redesigns and tests, et cetera. Do you have a feeling as to whether or not these changes could be satisfactorily resolved in time for a July 1987 resumption of shuttle flights? I think everybody wants the shuttle to move forward, but, boy, there's a lot in there, in these recommendations, prior to——

Mr. ROGERS. I think they can be implemented. I think they can be implemented quickly. I think they have to be.

And I think, as one of the other members of the committee suggested, it's a matter of mindset. I hope that the mindset of a lot of people at NASA has changed. We've got to get moving and there have to be changes made, and they have to be made quickly, I think.

I think one thing that we detected early on in the investigation which has changed was there almost was an attitude on the part of some people at NASA, based on their public statements, that the accident never happened; that the Commission was causing the problem. And I pointed out to some of them in private that we didn't have anything to do with the accident; we just came on later on, and it was a NASA problem. That's what caused the accident. That's where it happened. Those were the ones responsible.

Mr. RITTER. I'd like to ask astronaut Armstrong at this time—are we dealing with a climatological situation in this particular area of the country which is not conducive to an expeditious and efficient launch capability? I mean, I don't want to raise any hackles here, but there are a lot of people from Florida around——

Mr. FUQUA. I have to raise a point of personal privilege, Mr. Chairman. [Laughter.]

Mr. ROGERS. I forbid anybody on the Commission to answer that question. [Laughter.]

Mr. RITTER. Well, Mr. Fuqua, the distinguished chairman, and Mr. Lewis, my distinguished colleague are here, but you know we've just seen so many weather problems and so many temperature problems. At some point you want to say, "Is this the right spot?"

Mr. FUQUA. Will the gentleman yield?

Mr. RITTER. If the chairman allows me to take additional time, I certainly will to the distinguished chairman.

Mr. FUQUA. Well, maybe the Commission can explain where the ice came from because it didn't come from—it was cold weather, but it was not raining there. It came from an emergency shower that was left on to keep it from freezing, and the drain plug froze up and spilled all over and caused the icicles. So it was not necessarily a weather problem. Well, it was a weather problem that caused it, but it was not a——

Mr. RITTER. I would suspect that the weather kept the icicles there. [Laughter.]

Mr. FUQUA. Yes, it did. [Laughter.]

Mr. RITTER. If I could just reclaim my time and go on to the—you didn't comment, astronaut—I'm sorry, could you please?

Mr. ARMSTRONG. Well, with respect to your last question, it appears that the freeze protection system as implemented was imperfect and needs some changing, and I think NASA's fully aware of that and certainly will change that system that made the icicles.

The Florida weather has great advantages and its location has great advantages for launching. We've taken advantage of that for many years.

In the winter clearly the disadvantages that might be inherent were not well understood in this case; I certainly think they are now.

We've commented in the report about the vagaries of Florida weather at particular times of year with respect to recovery and made some recommendations in that regard.

With regard to your earlier question, which the chairman—to which the chairman replied, the safety recommendations with respect to tires, brakes, nose, wheel, steerling, main engine, orbiter valves, et cetera, are not new problems. These are problems that have been well understood by NASA for many years. There's been active work going on in all these arenas, and those areas—those are tough technical problems, but there are proposals to do something about them, and we support their efforts to do that.

Mr. RITTER. I would ask the Chair for additional time for one further question.

Mr. ROE. The Chair will allow the gentleman extra time.

Mr. RITTER. I thank the gentleman from New Jersey.

Scott Carpenter gave a speech up in my district not long ago, and he went through the views of an astronaut from outer space seeing spaceship Earth, understanding that you can't see any of the artificial boundaries, thinking about the family of man, and then he jumped to the conclusion—and it was the end of the speech and the question wasn't asked, but he jumped to the conclusion that the United States must be first in space. And I think I understand why, but I would like to get for the record your views, having been so closely associated with the program in its entirety. Could you tell us briefly why the United States must be first in space?

Mr. ARMSTRONG. Who did you say made that speech?

Mr. RITTER. Scott Carpenter, your resident philosopher for many years, as I understand. But he didn't really explain it.

Mr. ARMSTRONG. Well, not having the advantage of specifically what he said, it would be difficult for me to comment on his remarks.

Mr. RITTER. He didn't explain why. I guess that's why I'm asking you. He sort of took it for granted, but I wonder if the American people take it for granted. And maybe a brief explanation would be helpful.

Mr. ARMSTRONG. Well, I do believe this Nation does enjoy a preeminent position in spite of these recent difficulties in the past several months. Our technology is remarkable and has served our country very well over these past 30 years. I personally have had the privilege of participating in that, and all the advantages which I have received serving on this Commission have stemmed from my—the gift of my country to me in allowing me to participate. So it's not really for me to defend that, but just note that I'm happy it's happened.

Mr. ROE. The Chair recognizes the distinguished gentleman from California.

Mr. PACKARD. Thank you, Mr. Chairman. I was expecting someone from the other side.

I, too, simply want to compliment——

Mr. ROE. We happen to startle people that way once in a while. [Laughter.]

Mr. PACKARD. Well, I appreciate the chairman's consideration.

I want to add my compliments to the chairman and to the Commission and all of you for the responsible work you've done.

When we spoke of attitudes, I had to make a note because I just returned, along with some of my colleagues on the committee, from Friday at the NASA—at the Kennedy Space Center where we were briefed by the NASA team of investigators. A distinct impression we got at that briefing was that there was no preventable way or no means of preventing the accident. In fact, in their major findings and conclusions they state that there was no action possible that could have resulted in survival of the STS 51-L crew.

And you have made it very clear in our briefings previous to this and in your report, I believe, it was a preventable accident, and that attitude still distresses me and disturbs me, and certainly I feel that arrogance and independence in any part of NASA's organization must be changed because it interferes, I think, with the communication systems that you have very carefully addressed in terms of leading to the problem, or part of the problem.

In followup of my colleague, Mr. Ritter's, questions, your report clearly identifies the O-ring joint as the problem, as the cause of the accident, with other related problems in combination with that design problem and flaw. They've known that for 9 years, and yet nothing was done about it.

Did the Commission uncover other major flaws in the total system that have potential of creating another accident, may not have been contributory to this accident but have potential of creating other accidents, that have gone uncorrected on the same basis?

Mr. ROGERS. I wouldn't say on the same basis, but we did uncover other problems that we think could cause a future accident. We refer to those and we suggest that they should be considered and improved upon. And you will see in this last part of the report a lot of discussion about that.

Yes, I don't think we found anything of a similar nature, if that's what you mean. I don't think we found that other things that were serious and had been called to the attention of the top people where nothing had been done.

On the contrary, we found—I guess probably the thing we found most—and I'm talking really, and Neil should be talking because he knows so much more about the system than I do, but one of the things that always concerned NASA was the main engines. And they realized that there was potential for failure there right from the beginning, and they dealt with it pretty well, and it's been surprising I think to everybody that the main engines have worked as well as they have.

And we have encouraged NASA people to continue to look at all aspects of each one of these components to be sure that they were dealt with properly. Obviously one of the things concerning the astronauts—the brakes and tires and landing facilities, and particularly at Kennedy because of the weather——

Mr. PACKARD. Do you——

Mr. ROGERS [continuing]. So these things are all referred to in our report, and I hope that while NASA's in the process of redesigning the joints that they will be able to deal with some of these other problems which are also very serious.

Mr. PACKARD. Do you recommend that we do not fly until these other potential problems are corrected?

Mr. ROGERS. Not as such, because I don't think that was our task. I think the Administrator, the new Administrator of NASA, has to make these judgments. I don't think we should make the judgments in advance, but we certainly have pointed out areas of serious concern.

Mr. PACKARD. Another question, Mr. Chairman—the flight readiness review program requires that all of the decisionmakers sign off 2 weeks, I think, in advance of flight, literally sign that the systems are go. Beyond that 2-week period, advanced period, there is no signoff procedure up to flight time but simply an opportunity for them to make comments, but there is no ability for them to cancel the flight or to sign that they feel that the flight ought not to go.

Are you recommending that that system be changed to where the contractors and other major decisionmakers would have some input right up to flight time in terms of whether the flight should go or not go?

Mr. ROGERS. Yes. We recommend that all conversations of that kind be recorded from now on and that, in the case of Rockwell, for example, where they recommended—where they thought they recommended against launch, and the NASA people said they didn't understand it that way, that all those conversations be recorded, so that everyone in the loop will have the opportunity to vote no launch, and the vote should be clear and concise. It either should be we vote launch or no launch, and there should be no ambiguity.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished lady from Kansas, Ms. Myers.

Ms. MYERS. Mr. Chairman, I was very interested in your recommendation for a safety advisory panel, and I don't know how—what role you envision them playing or how it should be made up, but I would like to say in all seriousness I think that there would be an excellent role for members of the Commission on this safety advisory panel. Your background at this point, your understanding of the problems that went into the attitudes that developed, I think would mean that you would serve very well.

You made a comment at the beginning about how you are looking forward to returning to private life, but I'd like to say that I in all seriousness am suggesting that as a new job for you.

Mr. ROGERS. Well, thank you. I would like to suggest Mr. Armstrong. [Laughter.]

Ms. MYERS. I guess my question is, Could maybe both of you expand on the role of this safety advisory panel, because I think it's key to a—as a preventive measure, so that this won't happen again? Who do you envison serving and how? Would they actually be onsite? Would they be advisory only? And could you expand on that?

Mr. ARMSTRONG. Thank you. It's intended that this panel be a working panel; that is, not a full-time job but people that are actively and intimately involved in the organization and the day-to-day activities. As such, it would prevent—or I shouldn't say prevent, but it would certainly minimize the possibility of unexpected problems surfacing without an adequate safety review, similar to the question that we just previously asked about main engines and nose wheels, and so on.

We had intended that this be—although we were not specific about the membership, we indicated that it should have professional safety people, and we're thinking about NASA safety people, people out of the astronaut office, people out of the flight crew operations group and mission operations, the flight directors, and so on, people that are intimately involved everyday, and it will give a forum for anyone who has safety concerns about specific systems to have a court of appeals to get to and say, "Look, we're worried about this. We think it should be considered prior to flight."

It appears as though in past instances sometimes safety concerns were reviewed, evaluated, and, as NASA likes to say, dispositioned. But the people who had those concerns were unsatisfied. We think this court of appeals will give them a chance to have those concerns again reviewed.

Mr. ROGERS. Could I just also say that this recommendation resulted in large part from the concern of the astronaut office, and particularly Dr. Sally Ride, and I think it is, as you point out, a very important recommendation. We think the astronauts should be more actively involved in these decisions. Although on paper they seem to have proper recitement of responsibility, in fact they have not been as intimately involved in the program as they were at the time that Neil was in the program.

This is designed to be sure that there onhand—an in-house, onhand group of people available right there to deal with any of these things that might happen, and their voice will be very important and be listened to.

Ms. MYERS. I think, Mr. Chairman, in that if there is a villain in this, it seems to me that pressure is the villain, and I think you have identified that.

The attitude seems to have changed from one of total safety and "if you're in doubt, don't launch" to one of "we have to launch." The pressures were commercial, military, press, and I think Congress played a role in this pressure. Part of the pressure was for money; part of it was again a role that was referred to earlier—we've got to be first in space; we've got to get the payloads up.

My question is, did you determine how we can keep this pressure from building again? Because it will build again. The attitudes are still all there. And I sense it's starting already. We have already started talking about building a replacement orbiter. We've talked about we've got to get back into space again. So the pressures are beginning to build again.

How can we as a Congress keep this from happening?

Mr. ROGERS. I think that the oversight responsibility of the Congress is awfully important, but I think we also have to be careful, though, in our discussion of our pressures. In some ways pressures are what makes the American system work as well as it does. Everybody's under pressure of one sort or another, and I think it does create a lot of success, a certain amount of pressure.

I guess what we have to be careful about is undue pressure or pressure that overcomes your considerations of safety. And I think in an organization of this kind, where a lot of people are responsible, that's one of the risks, because you sort of are able to divide the responsibility. Here when you have so many people in the decisionmaking process, it's very easy for everybody to succumb to the pressure and say, "Well, we all agreed to it."

So I guess in answer to your question, I think Congress has a very important role to play in its oversight role, and I think don't the people are going to succumb to the pressure for a few years, but I think you're correct that as this program gets going again and is successful, and everybody begins to be optimistic, I think we have to be careful about that. And I would assume that Congress will be a major factor in seeing that doesn't happen.

Mr. ROE. The Chair recognizes the distinguished gentleman from Michigan, Mr. Henry.

Mr. HENRY. Thank you, Mr. Chairman.

Secretary Rogers, I'm wondering if in anticipating NASA's response if we might, first of all, divide the findings of the report from the recommendations. Are there any of the substantive findings of the report with which you believe, or have reason to believe, NASA is in substantive disagreement?

Mr. ROGERS. I don't believe so. I heard Mr. Fletcher this morning on television. He said he hadn't seen, been able to read all of it carefully, but he didn't seem to take issue with the report.

There may be people who, after they study it carefully, will have some reservations about it, but I rather doubt it.

Mr. HENRY. In the area of the recommendations of the report, are there any which you have reason to believe or your judgment would suggest would be bureaucratic or institutional resistance to the recommendations, any in particular, for example?

Mr. ROGERS. I don't think so. As I say, based on what we now know, I do not anticipate that, but it's always possible.

Mr. HENRY. On the issue of the kind of dilemma that NASA got itself into of increasing commitals in an environment of dwindling resources, to quote Mr. Armstrong, is NASA the innocent victim, or to what extent might this have been deliberate NASA bureaucratic strategy, as it were, to derive funds from the Congress by deliberately overcommitting and overextending in order to derive funds that were absolutely necessary to meet the commitments which had been made without cost levels being known to the Congress?

Mr. ARMSTRONG. I was not an employee of NASA during any of the years in question and cannot speak from personal experience there. I think it would be—it would be improper for me to try to make a judgment in that area.

Mr. HENRY. The gentleman from New Jersey mentioned that there are a number of people who have signed a bill appropriating funds for beginning a replacement *Challenger* shuttle type of vehicle. Without questioning the validity and the continuing need for a *Challenger* or Shuttle Orbiter Program, would it be prudent in your mind to commit these kinds of funds for a replacement or new vehicle until the fundamental questions posed and recommendations in your report are resolved, and above and beyond policy issues which your report raises, which in many respects are beyond the purview of the Commission relative to the role of expendable launch vehicles in meeting mission demands as opposed to shuttle orbiters?

I'm just wondering whether each of you would give me—at least I guess you can't perhaps speak for the Commission, but individually what your judgment would be on the wisdom of appropriating funds for a new *Challenger* until those fundamental programmatic policy issues are resolved.

Mr. ROGERS. I want to address—answer your question, if I may, first. I don't think we should make any judgments on the fourth orbiter because that was not our job. And I don't think we can disassociate ourselves from the Commission. The reason you're having us here this morning is because we're on the Commission, and I want to try as much as possible to be sure that we speak as a Commission, not as individuals. And we think that role is one that should be performed by Congress, not by this Commission.

Mr. HENRY. Let me rephrase the question, because I think it's very critical, given the kind of political climate that we face. And I think you're aware of that from looking at the history of the program, the public nature of the program, and—which obviously has been one of the factors which got us to where we are, both in a positive sense and a negative sense, but generally a positive sense. It's been a very important issue here.

And when we have this talk about being first in space, is it really irresponsible to suggest that commitments, a $3, $4 billion replacement issue, ought to be—the commitments ought to be withheld until we're resolved some of these fundamental issues which were inherent in some of the bureaucratic positioning that apparently was taking place in NASA—to try to handle all launches, all role missions in manned vehicles, the contest between NASA and the military as opposed to ELV's and manned shuttles? Aren't these policy issues that ought to be resolved before we preresolve them by committing vast resources of money?

Mr. ROGERS. I don't think we necessarily have to do it in that timeframe. I think that the recommendations of the Commission can be put into effect fairly quickly, and I also agree that—with your suggestion that some of these safety matters should be dealt with right away. I think that there should be a reassessment of the brakes and the tires and some of these other aspects, and I think that should be done. And if it requires more money, I think the money should be provided.

The thing I do not want to get involved in is the decision about the fourth orbiter. That's a function I think Congress should perform, and I don't think the Commission is prepared to make a statement on that.

Mr. HENRY. It's my understanding that roughly about 748 kinds of issues—[bell rings signaling time of the gentleman has expired].

Mr. ROE. Finish your question.

Mr. HENRY. Thank you.

There are some 748 issues on the criticality 1 list; that at one point the O-ring problem was on that list and was removed. Given some earlier comments you made that there are no known or discovered kind of safety flaws, kind of marginal risks equivalent to that, how could it be that the one most outstanding criticality problem of the list of then 749, to speak metaphorically, that that one item most critical should be removed from the list?

Mr. ROGERS. We can't answer that really.

Mr. ARMSTRONG. It was not. It was—permit me to——

Mr. ROGERS. Sure.

Mr. ARMSTRONG [continuing]. Make a technical correction. It was removed from the launch constraint list rather than the criticality 1. It was waived from the constraint list. It was not removed from the criticality 1. It was moved from criticality 1R to 1, properly so.

Mr. HENRY. Thank you.

Mr. ROE. The Chair recognizes the gentleman from Utah, Mr. Monson.

Mr. MONSON. Thank you very much, Mr. Chairman.

And I, too, would like to join with the others in expressing appreciation for the work that you've done and for the terrific service that it's been and for the excellent way that you've carried out that assignment.

I would like to know if you made any determinations as to whether or not there are any criteria that should be considered prior to a launch or in the design of any aspect of the shuttle or its components that are not now included as criteria to determine whether or not a launch should take place or in the design aspects.

Mr. ROGERS. I think, if I understand the question, we did in our first recommendation set forth some criteria on redesign of the joint, but I think that was the only one specific recommendation on a redesign——

Mr. MONSON. I'm referring to weather criteria or anything like that. Were there any—are there any factors that are not now included that you determined should be included in determining whether a launch should go forward or whether any design criteria should be met?

Mr. ROGERS. Well, as far—no other as redesign criteria. I think we have discussed with the NASA people—and I can't remember for sure whether it's in here or not— but that we felt that there should be more specific criteria for launches, particularly at Kennedy due to the weather. We feel that there should be specific questions, and they shouldn't be resolved on the eve of the launch, the day of the launch. They should be in place so that you would say—we didn't want to spell out exactly what they should be, but we did discuss whether any launch should occur at Kennedy, say, within 24 hours after freezing. That would be one way to do it. If there was a—if freezing conditions existed, you shouldn't have a launch for another 24 hours.

So I think NASA's aware that they have to look into those aspects of the weather, and I think we have made some references to the weather.

Mr. MONSON. Well, more specifically, we talk about ambient air temperature, but are there other temperatures that should be taken before a decision should be made to go forward with a launch? Wind conditions? I'm given to understand that perhaps one factor that entered into this was the violent wind shears that existed as the flight progressed that perhaps exceeded any previous experience. Is there any way to detect that, and should that be—have entered into the decision prior to the launch?

Mr. ROGERS. Well, we did—we had a lot of discussion about that, and we talked to the weather people. And they are going to try to get more accurate predictions about the weather. One of the problems is that they have some difficulty in determining wind shear at high altitudes, and they are improving the system of balloons that they have. They launch balloons so many minutes before the launch, and so forth, to determine that. And they are quite aware of that problem and I think will deal with it. It's not an easy problem, though. It's a very tough problem—to judge wind shears.

As you know, even in commercial aviation they have trouble with that, in predicting them in airports.

Mr. MONSON. Mr. Armstrong, did you have anything to add?

Mr. ARMSTRONG. I think the chairman hit the important points with respect to our criteria recommendations. They were first in the area of the joints, should the new design have joints, and, second, in the area of launch and recovery, particular emphasis on recovery at Kennedy and the criteria that should be established for that.

Mr. MONSON. With regard to your comments that NASA shouldn't have any more flights than their resources allow, given the resources that now are there with three orbiters and such, did you draw any conclusions as to how many flights are reasonable?

Mr. ROGERS. No; we discussed whether we should or not and we decided that we should not because it depends so much on developments. We certainly made it clear that we think they have to be more conservative. You probably read that Admiral Truly has made a statement, a policy, that they are going to be much more conservative in the future and they're going to limit the launches to the ones that seem realistic.

But we didn't think it was quite appropriate for us to run the program or to suggest. That will depend a little bit on developments, but I think they're going to be careful about it.

Mr. MONSON. Thank you very much, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Idaho, Mr. Stallings.

Mr. STALLINGS. Thank you, Mr. Chairman.

Mr. Rogers, I've not looked at the report as thoroughly as I'd like to, but I'm interested in the civilian in space. Did your commission discuss that question at all? And, to the best of your understanding, will that program continue?

Mr. ROGERS. Here, again, the NASA people have said that they are going to—for the next few flights they're going to have just astronauts on the launches.

We discussed whether we should make a recommendation on that. We finally decided against it because there were a lot of different opinions on the subject.

Up to the present time I don't believe that the civilians in space program has been an adverse safety factor. I don't think that's entered into—it certainly didn't enter into this accident. And we didn't think it quite appropriate to decide—I mean, I notice that some people say we shouldn't have anybody except astronauts unless you have the press or—and others that say, well, you shouldn't have anybody except astronauts except scientific people or somebody else. And I think that has to be a policy decision made by NASA.

I—speaking for myself, I think that the idea of teacher in space was an excellent idea. I think it would have been an inspiration for youngsters, teachers, and so forth. As it turned out, of course, it was very unfortunate, but I don't believe we as a Commission should make that policy decision.

Mr. STALLINGS. Perhaps Mr. Armstrong could talk about this, but I'm wondering if this is more of a public relations ploy, the teacher in space or some of the other civilian space programs, or if there is actual merit to those experiences.

Mr. ARMSTRONG. Mr. Stallings, I share the chairman's view. It was my sincere belief that this was a policy matter and it was beyond the purview of the Commission, and I prefer not to take a position on it.

Mr. STALLINGS. Thank you, Mr. Chairman.

Mr. ROE. The gentleman from Illinois, Mr. Fawell, please.

Mr. FAWELL. Thank you, Mr. Chairman.

I haven't had the opportunity—I suppose not many of us have—to fully digest what is before us here. And I know that basically of course you're dealing with the specific facts and don't want to get into policy.

Mr. Armstrong, you did make the statement, I think, at the commencement of these hearings that—and correct me if I'm wrong—that there has been a switch in philosophy, you feel, from a "can do" attitude, one where a launch was presumed unsafe until rebutted, until now it would appear that perhaps that mindset is that it's presumed safe until rebutted, which is an attitude of mind or a basic policy certainly.

When, in your opinion, was a switch made? Can you pinpoint it at all as to when this might have occurred?

Mr. ARMSTRONG. No, sir; I wish I could, but I only saw snapshots in the sixties, in the middle sixties, and now in the middle eighties. And I was not aware of what happened in between.

There are some differences, but there are many similarities, and I know that, for example, the management structure of the agency changed a number of times during the intervening period. The responsibilities, lines of communication, changed as Administrators and Associate Administrators, and so on, entered and exited the agency. Clearly, in the process of that, some of the procedures changed, but I am unable to be specific.

Mr. FAWELL. Mr. Rogers, do you have any comments in that regard?

Mr. ROGERS. No; I have less contact with NASA than Mr. Armstrong for sure.

Mr. FAWELL. At one time—and I haven't found this in the report—in fact, I must confess I heard it on TV last night, so that's how good my source is—but the statement was made that at one time there was a policy out of the White House that was unilaterally disbanded by order of President Nixon, and this particular observant said that this was quite a loss because we had some top lions that gave some policy and attitudes that perhaps we're deeply missing now.

And certainly the person at the top does an awful lot in setting attitude and policy.

Mr. ARMSTRONG. You're quite correct, sir. The act, as you will recall, provides—the act establishing NASA provides for the possibility of such a committee, and it did exist for some years and does not at the present time, and it's something that your committee may want to review.

Mr. FAWELL. Did the commission discuss this at all, the lack of such a committee in helping the unfortunate mindset, for instance, which we now apparently have at NASA not to develop or to rectify it?

Mr. ARMSTRONG. No, sir; this Commission did not look at that, but the Payne Commission did and I believe made a recommendation in that regard, the National Commission on Space.

Mr. FAWELL. Do you believe—again, this is perhaps out of your orbit—but the growing entry of the military into the use of shuttles, do you believe that this had anything to do with the increased pressure more than perhaps it should? Have you discussed—what about the future now that the military is certainly banging at the gates and very impatient about moving ahead?

Mr. ROGERS. Well, we discussed, of course, the idea that—the fact that the military payloads which were included in the space shuttle increased the pressure for launches. And we also pointed out that having sort of total reliance on the shuttle was not a wise judgment, and that will be changed in the future, because there are going to be more ELV's now in the picture.

So, to that extent, the answer to your question is, yes, we did consider that, and we think that will be changed now.

Mr. FAWELL. I just have one other—I think several people have expressed themselves in regard to the question of negligence or willful wantonness or whatever. The one phrase uttered by you, Mr. Rogers, which certainly caught me was your comment that Thiokol apparently changed their minds because they were trying to accommodate a major client. To me, if that is so, that flirts with willful wantonness, wouldn't you say so?

Mr. ROGERS. As I say, I don't—I've been out of the role of being a prosecutor for a long time, and I don't—so I don't want to be an authority on willfulness or gross negligence. I don't—it doesn't seem to me that prosecution would be successful of anybody in this tragic accident.

It's not beyond the realm of possibility that some ambitious prosecutor would think it was a desirable thing to do and make an attempt to do it. I don't think it would be successful. I don't think it would be in the national interest, and I hope it doesn't happen.

Mr. FAWELL. Thank you very much.

Mr. ROE. The Chair recognizes the distinguished gentleman from Virginia, Mr. Slaughter.

Mr. SLAUGHTER. Thank you, Mr. Chairman.

On the matter of pressure, with reference to the number of flights that NASA was planning, did the Commission find any definite indications of detrimental effects of the number of flights that were being planned and worked on?

Mr. ROGERS. I'm sorry, I don't think I understood the question, Mr. Slaughter.

Mr. SLAUGHTER. Well, I understand that one of the pressures that NASA was under was the number of flights it had scheduled; that they had cut back a number of times. But did the Commission find any definite detrimental effects of that heavy schedule that, orginally, NASA had decided upon that had any effects upon this accident?

Mr. ROGERS. Well, you know, you can't trace those things specifically, but I think that the fact that NASA could not maintain its schedule, was quite conscious of the fact of a lot of delays in their schedule, it wasn't meeting the schedule, must have played a part in the psychology of the people involved, so there would be a natural tendency to say, "Gosh, we don't want to slip up. We want to try to get these launches off as quickly as possible."

Now nobody said to himself, "Let's take a chance. This is going to—we've got to meet the schedule and, therefore, we're willing to take a chance that this going to be a catastrophe." Nobody said that, but it's quite possible that, being human beings, that they would react to the feeling that they had to meet the schedule.

Mr. SLAUGHTER. Thank you.

Mr. ROE. The Chair recognizes the gentleman from Pennsylvania, Mr. Walgren, the distinguished Representative.

Mr. WALGREN. Thank you, Mr. Chairman.

I would like to say at the outset how important a document, I think, and service you've provided to the Nation. My greatest fear at the moment of this accident was that we'd never have any idea what on earth happened, and at least now we have a very clear definition of cause and a very solid evidentiary framework from which to work.

Mr. ROGERS. Thank you.

Mr. WALGREN. Let me ask—is it the belief of the Commission that the O-ring failure and the failure of the joint was the real cause of this accident?

Mr. ROGERS. Yes. There is no doubt in our minds about that. I think everybody that worked on this has come to the same conclusion, and I hope that there will be no way to change that conclusion. I think it's a solid conclusion that is not subject to controversy.

You not only have initial puffs of smoke, eight puffs of smoke within the first 2 seconds, 2½ seconds, which coincide with the twang of the shuttle itself that has a—it's like a tuning fork, and those puffs of smoke coincided with that twang. So it's pretty clear that the joint failed at the initial stage, and then you see the plume and that comes about at the same spot on the joint, so you can identify that the smoke came from about a 300-degree mark on the joint. When you see the plume appearing, it's at the same spot, and it's clear that that plume means that that joint failed again, partly because of the wind shear, and that then acted like a blow torch and destroyed the strut, probably breached the external tank, the external——

Mr. WALGREN. Can you evaluate the contribution of the wind shear to the question or is the joint itself a sufficient cause?

Mr. ROGERS. Well, you can't be—you know, you can't say for certain that if it had been a totally calm day——

Mr. WALGREN. They might have made it through?

Mr. ROGERS [continuing]. They might have made it. But there's no doubt that the joint failed, and there's no doubt that the joint caused the accident. And we were concerned as a commission that we might come to that conclusion based on the evidence I just cited. Incidentally, the top part of the external—on the external—I mean of the booster hit the external tank, so there was a breach at the bottom probably caused by a strut breaking, and the collision at the top which indicated to all of us that that's what caused the explosion. So probably there were two breaches.

But then we were concerned that we might decide that and conclude that and then the debris would somewhere later on be discovered and it would turn out that our conclusion somehow wasn't correct. As it turned out, the debris confirmed exactly what happened because it's still at the same spot. So there can be no doubt——

Mr. WALGREN. I would like to emphasize at this point and note that you used words in the report like "the genesis of the accident," because I think that we have to follow that cause to really understand the responsibility for this accident in the long run.

And I am concerned that we, because of the emotions and the investment that we all have in the space program, that we will not define the responsibility in a way that it will change the attitude that you have pointed out in NASA, and that must change.

And I just would like to raise my little flag of warning that there's every indication that it's going to be a very, very difficult thing to change, and that the necessary degree of caution to be built into this problem shows every sign of yielding to the pressure and the emotions and the forces that would push beyond safe operation. And I hope this committee can play a role in preventing, to the ultimate degree that that's possible, that very thing from happening.

Thank you.

Mr. ROE. I thank the gentleman.

The Chair recognizes the distinguished Representative from California, Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

Mr. Secretary, I first want to join all of my colleagues in expressing my gratitude for your work on the commission, as well as the other commissioners, not only in terms of the results here, but also the great public service that you have rendered to the American public.

Mr. ROGERS. Thank you.

Mr. MINETA. Mr. Secretary, I'm anxious to have a more thorough understanding of the relationship between contractors and NASA. One question I have in this regard is, Is there a standard operating procedure pertaining to the launch readiness procedures that was woefully ignored in the 51-L mission and perhaps many times before?

In the case of SRB's, Thiokol was talking to level III people in NASA. On the other hand, it appears that Rockwell was talking directly to Level I people. Moreover, Thiokol was asked for written affirmation of their consent to fly. Rockwell was asked for no such assurances. And it is unclear to me that anyone spoke to the external tank contractors about the ice situation or, if so, what was the procedure.

Aren't there procedures, Mr. Secretary, which need to be established or perhaps newly adhered to in order to make this process less erratic and, more importantly, more reliable?

Mr. ARMSTRONG. If I may, sir, first, I think the flight readiness procedure as conceived and executed by NASA in general is a very good and comprehensive one. It really permits and requires every element at the foundations of the system, both contractors and Government agencies, to voice their approval in a formal fashion, in a pyramid style, until all elements are completely covered. I think it is a very good system.

We've revealed a few times when it worked imperfectly. I believe that we can say that in this case all the elements were interrogated and asked to provide their—any dissatisfaction they might have with the conditions forthcoming at the launch the day before. And both contractors did so, but as the report points out, in an imperfect fashion.

Mr. MINETA. You're careful to inform us that the level I decisionmakers were not informed about the O-ring problem and the temperature hazards. Now O-ring problems have been mentioned in reports in the past, and that full-scale briefings were conducted among top agency people.

I raise this point not to affix blame. I'm just trying to understand the information flow. It appears that the information flows upward in flight readiness reports which are naturally abbreviated, given the closeness to launch time, but is there a mechanism between launches where past readiness reports or past problems are reviewed to demand accountability for efforts to fix recurring problems or to explain repeated waivers?

Why do I have the impression that information only percolates upward at the will of middle management people without a corresponding accountability operating in reverse?

Mr. ARMSTRONG. You bring up a very good point, Mr. Mineta.

It was the commission's view that the information did probe—proceed forward, but was shortcutted. In the case of Rockwell, that information was conveyed directly on the moment of launch in response to the temperature concerns. That was level I because Level I happened to be at the meeting on the day before launch.

Mr. ROGERS. But also, just so we don't get confused about the levels, it's what—the point you're making is a good point, and that is, there was responsible level I, II for knowing things about this joint which they didn't do much about, so we don't want to put all the responsibility all level III.

But in the case of both contractors, they had plenty of opportunity to make their views known right up to the time of the launch. Morton Thiokol had already changed its view, so it didn't have anything to report. In the case of Rockwell, they did express views which turned out to be misunderstood, I guess.

Fortunately, from the standpoint of the Commission, fortunately, that did not contribute to the accident. Now there was a breakdown generally in how they dealt with the information about the past failures of this joint, and we try to point out in the report how that happened and we try to make recommendations to be sure it won't happen again.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Texas, Mr. Andrews.

Mr. ANDREWS. Thank you, Mr. Chairman.

I want to first join my colleagues in complimenting you, Mr. Rogers and Mr. Armstrong, and the other members of the commission for the job you've done. It's thorough, definitive, and very well done.

The irony of all this is that as we view, I suppose, man's worst space disaster, we stand right on the threshhold of some of man's greatest achievements in space. And I think, Mr. Rogers, your comments in your opening statement are very true. The real charge of this committee should be where do we go from here. How do we insure the safety of future crews and how do we make this system work for the future?

Specifically, you mention and recommend three things relative to the astronauts themselves—that they have a larger role in the decisionmaking process. You've recommended that astronauts become part of the management systems of NASA. You've recommended that they participate on the safety advisory panels, and that the flight commander himself have some say in the decision to launch or not to launch.

I wonder if you characterize the problem as it exists, or as you found the problem, as to the lack of input on the part of the astronauts and how you came to evolve in these specific recommendations for the astronaut corps.

Mr. ROGERS. Well, let me take them one at a time. In terms of management, we realize that there really are not very many astronauts in management now. Earlier on in the program there were some.

And we also learned that Admiral Truly, who has turned out to be really a superb executive, was in NASA and left because he really didn't feel he had an opportunity in management. So after this accident, he's been asked to come back and serve in NASA, which suggested to us that there probably are a lot of other astronauts who might like to go into management who would be superb at it and haven't had the opportunity. So we've urged NASA to consider the astronaut community as a source of excellent management material. Some may not want to, but there's excellent people there, well educated, experienced, knowledgeable. They know all the risks.

Second, we—although the astronaut office has been a useful office, we think that they have not had direct access to the top to the point that they should. There's sort of an intermediate level there. We want that office to have direct access to decisionmakers in all respects.

Third, we want them to be involved in the panel so they'll have immediate impact on launches and things of that kind, and we spell it out in the report.

So these are things that we have learned from our investigation. We worked very closely with the astronauts and the astronaut community, and I think they all feel that their views have been fully taken into consideration.

Mr. ANDREWS. You know, one of the things in testimony in the last few months—one of the astronauts testified that they have a procedure where the astronauts themselves overfly the site the morning of the launch to get a personal feel for the weather. And when they were asked what kind of input do you have, if you made that decision not to launch after that flight or during that flight—your senses, your instincts told you that the weather was not right, what kind of input do you have as to not to launch? And the response was that they did not know. They did not know how much impact their decision, their judgment, would play in that decision-making process.

Mr. ROGERS. And that's why, one of the reasons, we have the safety panel setup, and I'm sure that it will work. Everybody now is going to pay attention.

Mr. ANDREWS. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Texas, Mr. Barton.

Mr. BARTON. Thank you, Mr. Chairman.

I made a statement the day after the accident, the *Challenger* accident, that I would go up in the shuttle that day. Contrary to Mr. Boehlert, I'm trained as an engineer, have worked as an engineer in quality control, and have always had this absolute confidence that NASA and its procedures and its people were first rate and that safety was paramount.

Well, after following through the press and the briefings and your commission report and findings, and going over them, I don't have that confidence. I wouldn't go up in the shuttle today. Quite frankly, I'm not sure that we ought to be even thinking about continuing our shuttle flights until we're absolutely certain that everything is first rate again.

I think it starts at the very top. I think NASA's leadership has not intentionally, but just through time and the pressures that you referred to, begun to overload some of the safety problems, and I think safety has just not even become an issue.

In your report you talk about the silent safety program, and I think that's what it was.

So I am going to try to participate very fully in these hearings an insist that we reestablish leadership and that we reestablish safety as a critical importance.

With that as where I'm coming from, it's my understanding that one of your commissioners, Dr. Feynman, had some recommendations that were thought to be too inflammatory and so are not in the report. Now I have no problem with the recommendations that are in the report, but I would like to know what his recommendations are and why they're not in the report.

Mr. ROGERS. Well, I don't know whether you saw him on television last night. He was on the "MacNeil-Lehrer Report," and he explained that and said that he's perfectly satisfied with the report as written; he supports it. He wrote a paper which is going to be in the appendix to be labeled personal observations on reliability of the shuttle, and there really wasn't any problem with him. He said so.

This piece that he's done deals with—largely deals with probabilities of accidents, failures, and it's an interesting paper and should be in the report, and we all agree with it.

It didn't fit into the flow of the report very well, and it wasn't something that the whole commission considered as such, but there really wasn't any problem with it, and he said so last night.

Mr. BARTON. Well, if I could just quote from the New York Times, it says:

> At least one commission member, Dr. Richard Feynman, a Nobel prize winning physicist from Cal-Tech, is said to have objected to the deletion of some phraseology highly critical of NASA and to have complained that the commission has little evidence to support some of its praise of the agency.
>
> Although Dr. Feynman would not describe the nature of his objections, he said, "Mr. Rogers is worried that all of our recommendations and findings are so negative it will look like we're vindicative or carping or trying to kill NASA. I, myself, believe that's just the way the investigation came out."

I've read what has come out. I don't view it to be negative or carping. I think we need to have all the facts before us. And as you so well indicated yourself, you have conducted the investigation; it's up to us to set the policy, but we need to know all the findings.

Mr. ROGERS. I agree with that. And, as I say, we're pleased that all commissioners support this report, and Dr. Feynman support it enthusiastically. I think that it's quite remarkable that this group of people with such diverse backgrounds and so many talented people all came to the same conclusion unanimously without any exception, and we did try to present a balanced report. We've certainly not been easy on anybody. We haven't——

Mr. BARTON. I understand that. Well, let's go on. I assume at some point in time, Mr. Chairman, we will have Mr. Feynman before our committee and we can ask him about his recommendations.

Mr. ROGERS. Well, I hope that you—there's no reason not to have Dr. Feynman here. I would hope, though, that it doesn't—these things don't ever develop into such minutia. I think it's too important for the Nation.

We have—obviously in a commission of this kind we had numerous discussions about language, how do we state things, and we sat together for about 10 days and went over this report page by page and word by word, and there were all kinds of views expressed. To me, the remarkable thing is that we all agreed.

Mr. BARTON. Mr. Chairman, can I ask one question of Mr. Armstrong?

Mr. ROE. Yes; go ahead.

Mr. BARTON. If you had been the commander of the spacecraft on launch day and known about all the discussion that had gone on the day before, the night before, with regards to the O-ring, would you have made the decision to fly?

Mr. ARMSTRONG. I would have hoped that I would have been involved and aware much longer before, than just the night before, and had a chance to evaluate the problem and pass my own judgment on it.

It's hypothetical, and I don't know how I might have ruled had I been provided that information, but I certainly would have wanted to have had it.

Mr. BARTON. Thank you.

Mr. ROE. The Chair recognizes the distinguished gentleman from New Hampshire, Mr. Smith.

Mr. ARMSTRONG. Mr. Chairman——

Mr. ROE. The gentleman——

Mr. ARMSTRONG [continuing]. May I interrupt, sir?

Mr. ROE. Yes.

Mr. ARMSTRONG. I'd like to—Mr. Mineta asked a question, and I failed to answer it and I would like to acknowledge that I did and give him the answer, if I may, sir.

Mr. ROE. Of course. If the gentleman would withhold from New Hampshire for a minute, go ahead.

Mr. ARMSTRONG. He asked a question about the FRR's and the trend of information from previous flights, and that is an important point. And the FRR procedure is primarily to go back only to the immediate previous flight and review that information in a closeout of all open items since that time. And it neglected the exact point that you mentioned—what is the trend of events over a number of previous flights.

And in our report you'll find some recommendations with respect to trend analysis, and we suggest that that properly should be the function of a good safety organization and they should be doing that monitoring as a part of the FRR process. And I wanted to get that point in because I thought it was significant and——

Mr. MINETA. That is encouraging, Mr. Chairman, if I might add, because I Chair the Aviation Subcommittee. And when FAA goes over the reports of the airlines, when you have these deferred items carried over from one report, from one airplane, from the same airplane, from one time period to another, then you can see why things like the Eastern Airlines and the $9.5 million fine and 78,000 violations occur, because they have deferred maintenance items that have just stayed there consistently over a long period of time.

Mr. ARMSTRONG. Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman from California.

The gentleman from New Hampshire.

Mr. SMITH. Thank you, Mr. Chairman.

Mr. Secretary, I'd like to join the chorus of those who have been commending you. I think the President chose wisely, and I comment you and your entire committee for the work that you have done.

I, as a layman in this matter, both in a congressional oversight responsibility as well as just a private citizen—I find a strange inconsistency in this thing about safety over the past several years, and I don't know many—was it 50-some-odd manned space flights—we get down to countdown and we have countless delays, postponements, sometimes cancellations, and safety always seemed to be the thing on the front page—we didn't fly because something wasn't right.

What was different this time? Were we lucky for the past 20 years or so? Were these flights—were we just plain lucky and we were doing things wrong all along or, if not, what was different this time?

Mr. ROGERS. Well, it's difficult to answer that in a word. What we are trying to do in this report is to answer it. I mean, we would hope that the American people are interested in it, would read the report, and I think the report does answer that question. I don't think it's possible to answer it in a word or in a sentence or in a chapter. I think you have to read it all to come to your conclusion. And I think the report does answer that question.

Mr. SMITH. All right. You made a statement which kind of jumped out at me and caught me by surprise, frankly. And I'd like you to just make sure you meant it and——

Mr. ROGERS. I probably didn't.

Mr. SMITH. No, you made a statement which—I wrote it down—you said, "Budget cuts probably did impact safety at NASA."

My question——

Mr. ROGERS. Excuse me. I couldn't quite hear you.

Mr. SMITH. "Budget cuts probably did impact safety at NASA."

And my question is this: we've sat here over the past several months, several years for many of us, and never heard that from NASA, never heard that from a countless number of witnesses who have come before this committee.

Can you give me some specifics as to why you might come to that conclusion?

Mr. ROGERS. Well, I guess you can—you can always argue that you have more money, you can do a better job. So maybe my answer was premised on that thought, but I think that there's more to it than that.

In this case we examined two aspects that—specifically, one was the fact that they're cannabalizing the orbiters; in other words, taking parts from one shuttle, putting them in another because they don't have spare parts and they don't have enough orbiters. So cannabalization is a very dangerous process. You have to make all kinds of adjustments when you do it.

So certainly if they had—they'd asked originally for five orbiters and they didn't get them. So if you cannabalize, take parts from one to the other, put it in the other, it obviously is dangerous. It has some tough aspects.

Furthermore, they are running short of spare parts. Now why they were running short, I'm not sure, but they say that they're running short because of budgetary considerations. And there's testimony before the Commission that if they would have had to continue the program at full speed, that they were going to be running out of spare parts, and it would have been dangerous. And that's in the report, too.

So I think my answer was based on those facts. I can't say that specifically it was budgetary in this case, in the case of the *Challenger*, but you certainly could say over a period of time, maybe if they had had five orbiters and a little more money, it would have been a safer operation.

Mr. SMITH. did anyone that you spoke to in the course of your investigation from NASA or from any other witness—any other witness that you asked that question, did anyone give you a yes to that question? Did they say, yes, budget cuts did impact safety? Did anyone say that?

Mr. ROGERS. I'm not sure they used that word, but they—and they didn't say it in connection with the *Challenger*, but they said it in generally speaking, yes, sure; the astronauts did.

Mr. SMITH. Because I think from a congressional oversight responsibility, Mr. Chairman, I think my concern here would be when we have the experts coming before this committee not ever saying that to us, my concern is I think we should be interested more in priorities. We certainly would have canceled some other mission, not necessarily dealing with the orbiter, but perhaps some other project in the whole scope of the budgetary process with the whole program of science and technology perhaps to focus in on safety. And so I think—it is not meant to be directed at your committee, but I think that at the congressional oversight level, I think we have a lot of work to do, because I have some real concern about this being almost a—we were caught up, as somebody said before, in the momentum here of everything's going well, all these successes, and now we're—just keep moving. And I think this committee, frankly, this congressional committee has been caught up in that, and I was very much surprised to hear that, but I think that will certainly change my attitude.

Mr. ROGERS. I want to be sure, if I may, make one more response—want to be sure that I'm not suggesting that budgetary considerations played a part in this accident. I wouldn't want to leave that impression.

Mr. SMITH. May I ask one quick, followup question? I know we're out of time—but just one quick question.

Mr. ROE. The gentleman from New Hampshire?

Mr. SMITH. Did you have any evidence that the crew would have had any inkling of this O-ring problem in the flight? I have not read your report in its entirely, so if it's in there, I could go back. But was there any inkling at all in that 70-some seconds that the crew—would the pilot have had any possible ability of knowing what was going on?

Mr. ROGERS. I don't think so.

Mr. SMITH. Thank you.

Mr. ROE. The Chair recognizes the gentleman from Illinois, Mr. Bruce.

Mr. BRUCE. Thank you.

Mr. Rogers and members of the Commission, I join with the others in commending you for the fine work that you've done in determining the cause and recommending corrective actions for Congress. Now we have to evaluate and fund many of your recommendations, and so my questions really are some questions that deal with the power of the purse that we have.

It seems that eight of the nine recommendations that you have made to us entail increased cost, and at least in two of the recommendations, recommendation No. 1 on design and No. 7 on crew escape, you ask NASA, and indirectly the Congress, to take a different look at how we consider cost. You've observed through your review a number of wasteful practices at NASA. And can enough waste and mismanagement be eliminated at NASA as it presently is formulated to make a mission acceptably safe within the current budget levels?

Mr. ROGERS. Mr. Bruce, I really don't have the capabiity of answering that. I don't know enough about the subject to answer it.

Mr. BRUCE. In your review did you find any practice at NASA that should be brought to our attention, that we should look at in the way of waste within NASA, problems they have with overexpenditure?

Mr. ROGERS. I didn't. Possibly Mr. Armstrong—see, we really didn't have the mandate of looking at everything. We were not an oversight committee to review everything about the shuttle. We were asked to deal with the accident, how to prevent future accidents. We didn't go into whether they were doing it in an extravagant way or not. So I just don't—I don't have the ability to answer it.

Mr. ARMSTRONG. I have to agree with the chairman. I don't think we have the basis for passing a judgment, but as a footnote to that comment, let me just say that it seems to me that it's important not only to ask, can you do this job with this kind of money, but, secondarily, can you do this job with what level of confidence with this kind of money. Because the additional funds that are provided to do a particular program are used to pay premiums on additional insurance policies basically, doing additional testing, getting additional confidence in the abilities of the systems to do the jobs, and so on. And so I suggest that you demand agencies, when they come before you, to try to in some way quantify what level of confidence they might have with that level.

Mr. BOEHLERT. Will my colleague yield on that for just a moment, please?

Mr. SMITH. I'd be happy to yield.

Mr. BOEHLERT. Mr. Secretary, I'm glad you said that budget considerations did not appear to play a part in this accident, because, according to a staff report we have—and I would like to just read a portion of it—

"NASA engineers and management were aware of the joint problem in 1978 and had observed O-ring failures in the form of erosion and bypass during tests and after flight; yet, NASA procedures were ineffectual in correcting the problem prior to the STS 51-L accident."

So that doesn't seem to be directly related in any way, shape, or manner to budgetary constraints. As a practical matter, for the last 5 years we've increased the budget for NASA, although I understand because of inflation it really boils down to level funding. But I think that's important to have that on the record, Mr. Secretary, and I'm glad you emphasized that. Thank you.

Mr. ROE. The gentleman from——

Mr. BRUCE. One question on safety: your recommendation, your second recommendation is that we would establish a shuttle safety panel. Your fourth recommendation that we start an office of safety with an associate administrator.

I also saw the program MacNeil-Lehrer last night, and the discussion that occurred in that program concerned me in that at least one former astronaut indicated that he thought that was a mistake, that the recommendation of an office of safety would allow people up and down the line to say:

Safety is not my watch. That's someone else's problem, so let's—the safety office is in charge of that. As long as they sign off on this, my rear end is covered so let's not worry too much about it.

Was there any discussion within the Commission about that particular aspect of safety? And I'm also concerned about, What is going to be the coordination between the office of safety and the shuttle safety panel?

Mr. ARMSTRONG. I believe that was Dr. Hans Mark, Associate Administrator, that made that comment. And his concern was that which was stated by the chairman earlier; namely, safety has to be everybody's business, and you can't delegate the responsibility for safety to some organization off to the side and expect safety to be done. And we certainly as a Commission agree with that approach.

It's felt, however, and the organization that the Commission has suggested is one in which the safety organization would act like an independent audit function in the business world; that is, an outside, independent audit or an internal audit firm that has not line responsibility or sale of products or services, or whatever. And we believe that's important.

The safety panel, on the other hand, is a completely animal. It's intended to be an organizaiton within the line, although it will have safety individuals in it, that acts on day-to-day safety concerns of individuals, contractors, and Government agencies, NASA organizations wherever they occur, and gives them a court of appeals to bring their concerns and have a hearing.

But they would not be within the office—they would not be a part of the safety stream, which would be the independent audit; no, sir. It's a working level.

Mr. ROGERS. Can I also say that I heard that "McNeil-Lehrer Report," too, and I heard what he said. I don't—I disagree with him, quite strenuously disagree with him.

At the present time the chief responsibility for safety, granted that everybody has to be responsible in part for safety, but if everybody's responsible you end up with nobody's responsible.

The chief engineer at the present time at headquarters is now responsible for safety. He's the man that is looked to as the safety officer for NASA. He said—and we cited in the report—"If I had known, I'm sure that in the 1982 time period when we first came to the conclusion that the seal was not redundant, I would have insisted that we get busy right now on a design change and also look for any temporary fix we could do to improve the operation of the seal."

He didn't know about any of these things. He was the chief engineer. What we are saying is that there should be one person in headquarters who is primarily, all of his responsibility has to do with safety. Now even that system can break down, but there should be some responsible person that should know about these things. They should know all about them. They should have known all of the problems they had with the seal over a period of a long—a period of years.

As a matter of fact, there were aspects of this seal where they had been—or these seals, whether they're in the field joint or the nozzle joint, which is somewhat the same— there had been problems with them, out of the 24 flights, problems on 14 of the flights.

And what we're saying is there should be some person at the headquarters whose job it is to say, "My God, it's my problem. I want to know what's going on. You've got to let me know it. If you don't let me know, it's your scalp. I'm the man that's going to be responsible at headquarters."

And we think that's an important recommendation.

Mr. BRUCE. May I make one final—I take it from what you say this is very important not only to create that office, but we elevate it to the level of Assistant Administrator?

Mr. ROGERS. Absolutely.

Mr. BRUCE. OK. Thank you.

Mr. ROE. The Chair recognizes the gentleman from—the distinguished gentleman from Ohio, Mr. Traficant.

Mr. TRAFICANT. Thank you, Mr. Chairman.

As the only member from Ohio, I want to welcome not only the Commission members for the fine job you've done, but give a real hello from Ohio to Mr. Armstrong who helped America before tremendously and is helping now, and we appreciate it.

You know, as we look back—and now we're talking about the fault and the causations of this tragedy, and we talk about the O-ring. I'm going to offer my opinion and then I'm going to ask you for your opinions. I don't believe the problem was the O-ring. I believe the problem was the management of NASA. I believe everybody should take off the gloves and do what we can to correct the problem before this type of an incident could occur again.

Now this is very unpopular in America—to question NASA. It's been up on that ivory tower, but now we've come to see that some of the management perspectives that loom within NASA are as regular as some of the other more mundane types of agencies such as the IRS and others. And, my God, we can't afford that.

I refer specifically now to something that I consider to be very, very important in this report. It's on page 10, approximately halfway down, and it refers to the launch decisionmakers not being made aware of certain things.

I want to quote something from this report and then ask that opinion and make a recommendation, Mr. Chairman. I quote:

"These launch decisionmakers," the statement says, "were unaware that Thiokol, including management officials, originally recommended not to launch and then, when pressed by NASA"—when pressed by NASA—"that Thiokol management reassessed and recommended to launch."

My point is we live in a time of government where the outside contractors almost sometimes overly influence the agencies, sometimes illegally.

Here's a case where at least at the subordinate level the engineer says, "My God, we've got a problem. Let's not take this thing on." But it was NASA and NASA who pressed that ultimately brought about this launch. I find that to be the cause of the problem and the cancer there.

Now in your opinion, what can this committee and the House do, what can we do as elected officials and the representatives of the people here—what can we do to deal with the management perspective within NASA to try and bring this ship to order, and what are those specific recommendations that you might make to us in that regard?

Mr. Rogers, Mr. Chairman?

Mr. ROGERS. Thank you. Let me say, first, that in one respect the question you ask is even worse than you made it seem because originally it wasn't just the engineers in Thiokol that recommended against the launch; it was everybody in Thiokol, including management. It was a unanimous recommendation not to launch, and that recommendation, unless the temperature was 53 degrees or more. So it wasn't just the engineers fighting management; it was a unanimous decision by that company that that shuttle should not be launched.

Now the change occurred not—the engineers didn't change their mind, except Mr. Lund who happened to be part of management, but they changed their mind because NASA said that they were appalled at the recommendation and, if the recommendation stood, they might not be able to launch until April. And after those things were said, Thiokol management changed—made a change—changed its mind. And they signed the telefax that said that it was okay to launch.

Now I—in answer specifically to your question, I think it's a matter of changing the attitude on the part of everybody, and certainly in the case of NASA. I think that contractors have to be aware of their responsibility; NASA has to be much more aware and take it into consideration, and I think our report, would hope our report, will serve that function.

We hope that the new leadership in NASA will understand the risks of proceeding on any situation that's not safe. And we hope that everybody who has the responsibility of deciding to launch the shuttle in the future will know all the facts before they make the decision.

They still may make a mistake. It's quite possible. But they certainly should make the decisions based on known facts at the time. We hope that the work of our Commission will serve that purpose.

Mr. TRAFICANT. For the purpose of time—it's very limited, Mr. Armstrong—I'd like to ask you to maybe move off another quick question.

It is always the key question that deals with morale. No matter what the element you deal with, the attitude of the people within has much to do with the intended outcome. What is the morale of NASA? In your opinion, what is it going to take to involve the—all elements to make them into one key, cohesive unit that has some decisionmaking input?

Mr. ARMSTRONG. I haven't taken any kind of a formal survey and can't really give an enlightened response to that, but I have had the opportunity to talk to a number of individuals during the course of the investigation, and I'm encouraged. The people I talked to are—were pleased that the Commission was taking an aggressive approach to uncover the facts, and they were disturbed by some of the things that we found and that they found as a result of the inquiry. But they all universally—those that I talked to generally felt they wanted to get on with the job, make the fixes, and they'd feel a lot better when the fixes were in and they were back in flying.

Having said that, I don't want to imply that there probably aren't those who will change their mind about their participation in some way or other, because there probably will be, but I just do not have those facts.

Let me make one additional comment with respect to your previous question. I wouldn't want this committee to feel that the Commission thought that, had we in fact waited and always launched at temperatures greater than 53 degrees, or some number, that this would have been a safe design. In fact, the Commission concluded the opposite—that there was inherent design deficiencies in this joint and they need to be fixed, no matter what temperature it's flown in.

Mr. TRAFICANT. Thank you.

Mr. Chairman, I have a recommendation for the Chair, whether it's in order or not. I would recommend the Investigation and Oversight Subcommittee of this committee look into the management perspective and the decisionmaking that had gone on along with this particular launch, if necessary behind closed doors, and take a real good look at it and try to get to the bottom of that management aspect.

Mr. ROE. If the distinguished gentleman would yield, tomorrow we're going to have before us the leadership of NASA, and we're going to get into these program problems in the same kind of depth, and I trust you'll be here to propound your excellent questions.

The Chair recognizes the distinguished Representative from Kansas, Mr. Glickman.

Mr. GLICKMAN. Thank you.

Mr. Rogers, years and years ago you were at George Washington University Law School the judge of a moot court argument I made and I lost it. [Laughter.]

So now that you're back——

Mr. ROE. You'd better quit while you're ahead. [Laughter.]

Mr. GLICKMAN. I'm not sure what that means.

Mr. ROGERS. Somebody was looking for a thorn in the flowers we were getting; maybe you're it. [Laughter.]

Mr. GLICKMAN. No, I'm—actually the country owes you a great deal of gratitude.

Before I ask you two questions, I'd just like to again make public reference to a couple of points: one on page 201, one of your recommendations is reliance on a single launch capability should be avoided in the future. That is a very significant recommendation and one that will cause us a great deal of major public policy choices, whether we go transatmospheric vehicle, expendable launch vehicles, no fourth orbiter, cut the shuttle totally, more unmanned spaceflights, and let us hope that the legislative process and executive process can deal with those questions rationally and independently, because you've raised them here and they are truthfully public policy questions.

Second of all, while it's been touched before, the role of Congress—I also agree, we have not approached this from an adversarial or at least from an independent role, but it's no different here than it is with almost anything we're involved with. When we're involved too closely, we lose the independence.

I recall a number of times NASA took me down on airplanes to see the space launch, and that was all very nice. Then I think to myself, but the whole idea was, on both of our sides, to establish cozier relationships so maybe we wouldn't be as independent as we should be. And I think that that has to be part of it.

But let me go to a couple of questions. After reading this report, I don't see one darn word about contractors. It almost looks to me like you have neglected any reference to the contractors—to Morton Thiokol, to all the other contractors who were involved in the situation.

And I'm just wondering, Is there some reason why you have seemed to have left them out of this chain? And maybe I haven't read the report as well as I should have, but what about the contractors? What about the relationship between the contractors and NASA? Should they expect something new and do you recommend something new as a result of this?

Mr. ROGERS. Well, I do think that you missed some of the comments in the report, but we do single out Morton Thiokol particularly. We have a lot of discussion in here about them. And we say something that's judgmental, I guess. We say that the contributing cause of the accident—we say, "The Commission concluded that the Thiokol management reversed its position and recommended the launch of 51-L at the urging of Marshall and contrary to the views of its engineers in order to accommodate a major customer."

Mr. GLICKMAN. OK, that's true, but there's nothing in your recommendations to recommend any structural changes in the relationship between the contractors and NASA, and I think that goes to at least part of the heart of what happened here. And I'm wondering why.

Mr. ROGERS. Well, I'm not sure that I understand the term "structural change." NASA has the responsibility of making contracts with contractors that perform their functions properly. And we did—we reviewed the Martin Marietta performance on the external tank, and we had testimony from them, and we were quite impressed with the fact that they were very thorough. They did what appeared to be a good job over the 24 previous flights, and we also reviewed and have some references here to other contractors.

Now I don't think we undertook to try to determine whether NASA made the right choice of contractors because I don't believe that was our——

Mr. GLICKMAN. That's not my question. My question is that NASA operates very much like the Defense Department and to some extent like the FAA in terms of its relationship with major, substantial, outside contractors, and clearly in this case that relationship affected the lack of success of this flight. Now part of it was the flaw on the management, but part of it may have been the flaw in the relationship between management and the contractor. And I'm just, frankly, at this stage disappointed why there wasn't any specific reference. Maybe that wasn't in your frame of reference at all, and——

Mr. ROGERS. It really wasn't. As I say, my thought was that we were pretty rough on Thiokol. I mean, they certainly think we were.

Mr. GLICKMAN. Well——

Mr. ROGERS. I think that when you read this carefully, you'll see that we didn't recommend any change be made. We think that's a matter for Congress, and Congress already has had some discussions about that.

Mr. ROE. Will the gentleman yield?

Mr. GLICKMAN. I will be glad to yield. I just have one more——

Mr. ROE. I think it's important to point out for the gentleman—I know you were a little late in getting here—I think it's important to point out to the gentleman that in the overall scoping of the efforts to be performed by this committee and all its members, we are listening to the distinguished representatives in Secretary Rogers vis-a-vis their work. We will be calling in NASA tomorrow to respond, and there's plethora of questions that members have propounded that only NASA can direct its attention to.

Third, if the gentleman will yield, we will be calling in an astronaut corps, both retired and present astronauts, to get their particular point of view and their observations, using the basis of the Rogers report.

And then, fourth, we definitely will be calling in the private sector vis-a-vis the manufacturers of all phases of this work to get their reaction.

I think in fair play it's important that each one has their chance at the morale justice of the——

Mr. GLICKMAN. I appreciate that. I guess my only point is that these recommendations on pages 198 to 201 are going to be the ones that are copied and sent and disseminated all over the place, and not once is there a reference to that kind of structural relationship between NASA and the contractor.

Mr. ROE. If the gentleman would yield again, if the gentleman would read very carefully what the charge of the President of the United States was to the Commission, that would help to clarify his concern, I think.

The responsibility of the Commission was to thorougly review and exhaust and recommend their exact findings as they relate to the accident per se. I think one of the great achievements of the Secretary and his colleagues in forming their report is that they have uncovered in a very scholarly manner a number of items which we have to look into. And the one you're mentioning I'm not—and you'll get another minute or two——

Mr. GLICKMAN. OK, thank you.

Mr. ROE. I'm not denigrating your observations. I'm just simply saying that that avenue is open. I mean, we can't explore the regrets of——

Mr. GLICKMAN.. OK. And I'm not saying that you ignored it intentionally—not to deal with it.

Mr. ROGERS. No, we didn't.

Furthermore, I think you should have won the debate. [Laughter.]

Mr. ROE. On that basis——

Mr. GLICKMAN. Boy, didn't you soften me up. [Laughter.]

Now this is the last question.

Mr. ROE. On that basis, I think you just lost the debate.

The gentleman from Kansas?

Mr. GLICKMAN. It seems to me another issue has to do with the relationship between management in the NASA Program and management in the Defense Department.

For example, it almost seems to me that what we've seen here is that the people who worked at the center were more concerned about the center than they were about the program. And it looks to me like DOD management is geared just toward the opposite—that DOD management is more geared toward the program and not the center.

And you've talked about some of these things generally. I wonder if you might comment on that and also comment on a possible suggestion as to whether the Department of Defense—this may be heresy, but I'm going to ask you to comment on it anyway—whether the Department of Defense should take over the operations of the shuttle and/or the operations of NASA and operated, it being in charge.

Mr. ROGERS. Here, again, I really do think that's outside of our mandate. We did not address that and I don't think we should.

Mr. GLICKMAN. OK.

Mr. ROGERS. I think that's—those questions really are policy questions that Congress has to decide.

Mr. GLICKMAN. All right. Now what about the first part of the question about the way the management structure was oriented people were more concerned about the center they worked for rather than the program that they worked for, where there was a delineation of goals?

Mr. ROGERS. We do make reference to that. We recommend that more responsibility be given to headquarters, and particularly we think that the center at Marshall is probably too autonomous and needs to be looked at very carefully.

Mr. GLICKMAN. Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman from Kansas.

If there are no further questions, the time has become—we've come to the end of our time.

Mr. Secretary, I want to thank you and your vice chairman, Mr. Armstrong, for very adroit, candid, upfront testimony. We think you did a splendid job.

We've exhausted our work for today. I know your work is not exhausted for today.

I want to thank you very much. We're not sure whether we'll be wanting you back on Thursday, but we'll keep in touch with you.

Mr. ROGERS. We hope you don't, very much. We want to get back to private life.

Mr. ROE. I understand.

Mr. ROGERS. Thank you very much.

Mr. ROE. Thank you very much.

The meeting stands adjourned.

[Whereupon, at 12:37 p.m., the committee recessed, to reconvene the following day.]

INVESTIGATION OF THE CHALLENGER ACCIDENT

(Volume 1)

WEDNESDAY, JUNE 11, 1986

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The committee met, pursuant to recess, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Robert A. Roe (acting chairman of the committee) presiding.

Mr. ROE. The committee will come to order.

Good morning, ladies and gentlemen. This is the second day in a series of hearings that the Science and Technology Committee is holding to investigate the shuttle *Challenger* explosion.

Our Nation has a commitment to space exploration and space development, and we must maintain these objectives even as we examine the causes of the shuttle accident.

As I mentioned yesterday, our approach will be three pronged. First, we will examine the accident in terms of technology and hardware, which is the process we're on now—really, what went wrong. Second, we will scrutinize the role of NASA's management and decisionmaking process in the accident scenario. And finally, we will use this knowledge to help us make the decisions and judgments necessary for the future stability and success of our Nation's Space Program.

Yesterday we heard from the Honorable William Rogers, Chairman of the President's Commission on the Space Shuttle Accident. The Commission has provided the Nation with an outstanding documentation of the technology failures and also management problems that led up to the January 28 accident. Today, NASA Administrator James C. Fletcher is with us to respond to the findings and recommendations of the Rogers Commission report, as well as to present his views on changes and ideas and suggestions on NASA's future structure and operations. And I understand that with Dr. Fletcher will be Dr. William Graham, Deputy Administrator, NASA; Rear Adm. Richard Truly, Associate Administrator for Space Flight; Mr. Arnold D. Aldrich, manager of the National Space Transportation System of NASA; Capt. Robert L. Crippen, astronaut, NASA; and Mr. Dan Germany, leader, photo and TV analysis team, from NASA, in due course as they fit into the testimony.

[The prepared opening statement of Mr. Roe follows:]

OPENING REMARKS
OF
HON. ROBERT A. ROE
HEARINGS ON CHALLENGER ACCIDENT
JUNE 11, 1986

THIS IS THE SECOND DAY IN THE SERIES OF HEARINGS THAT THE SCIENCE AND TECHNOLOGY COMMITTEE IS HOLDING TO INVESTIGATE THE SHUTTLE CHALLENGER EXPLOSION. OUR NATION HAS A COMMITMENT TO SPACE EXPLORATION AND SPACE DEVELOPMENT AND WE MUST MAINTAIN THESE OBJECTIVES EVEN AS WE EXAMINE THE CAUSES OF THE SHUTTLE ACCIDENT.

AS I MENTIONED YESTERDAY, OUR APPROACH WILL BE THREE-PRONGED. FIRST WE WILL EXAMINE THE ACCIDENT IN TERMS OF TECHNOLOGY AND HARDWARE. WHAT WENT WRONG? SECOND, WE WILL SCRUTINZE THE ROLE OF NASA'S MANAGEMENT AND DECISION-MAKING PROCESS IN THE ACCIDENT SCENARIO. FINALLY, WE WILL USE THIS KNOWLEDGE TO HELP US MAKE THE DECISIONS AND JUDGMENTS NECESSARY FOR THE FUTURE STABILITY AND SUCCESS OF OUR NATION'S SPACE PROGRAM.

YESTERDAY, WE HEARD FROM WILLIAM ROGERS, CHAIRMAN OF THE PRESIDENT'S COMMISSION ON THE SPACE SHUTTLE ACCIDENT. THE COMMISSION HAS PROVIDED THE NATION WITH AN OUTSTANDING DOCUMENTATION OF THE TECHNOLOGY FAILURES AND ALSO MANAGEMENT PROBLEMS THAT LED UP TO THE JANUARY 28TH EXPLOSION.

TODAY, NASA ADMINISTRATOR JAMES C. FLETCHER IS WITH US TO RESPOND TO THE FINDINGS AND RECOMMENDATIONS OF THE ROGERS' COMMISSION REPORT, AS WELL AS TO PRESENT HIS VIEWS ON CHANGES IN NASA'S STRUCTURE AND OPERATIONS.

WITH DR. FLETCHER ARE DR. WILLIAM GRAHAM - NASA DEPUTY ADMINISTRATOR AND NEWLY DESIGNATED SCIENCE ADVISOR TO THE PRESIDENT, REAR ADMIRAL RICHARD TRULY - NASA ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, MR. ARNOLD ALDRICH - NASA MANAGER OF THE NATIONAL SPACE TRANSPORATION SYSTEM, AND CAPTAIN ROBERT CRIPPIN - NASA ASTRONAUT.

WE INTEND ALSO TO CALL UPON NASA'S SHUTTLE CONTRACTORS AT A FUTURE DATE.

THE ROGERS' COMMISSION, NASA, AND THE CONTRACTORS ARE THE THREE MAJOR COMPONENTS THAT WILL PROVIDE THE COMMITTEE WITH THE COMPREHENSIVE PERSPECTIVE IT IS SEEKING IN THIS INVESTIGATION. HOWEVER, THIS DOES NOT PRECLUDE ANY DECISION WE MIGHT MAKE TO CALL UPON OTHER INDIVIDUALS OR GROUPS WHO MAY SHED FURTHER LIGHT ON OUR INQUIRIES.

GENTLEMEN, WE ARE PLEASED TO HAVE YOU WITH US TODAY.

NOW I WANT TO RECOGNIZE CONGRESSMAN LUJAN, RANKING REPUBLICAN MEMBER OF THE SCIENCE COMMITTEE.

Mr. ROE. Before I call on our distinguished witnesses today, I defer to our ranking minority member, Mr. Manny Lujan from New Mexico for any opening statement he may wish to make.

Mr. LUJAN. Thank you very much, Mr. Chairman, and I join you in welcoming Dr. Fletcher and Admiral Truly before this committee today. I look forward to hearing their initial responses to the conclusions and recommendations made by the Rogers Commission as a result of its investigation into the *Challenger* accident.

I was glad to hear that Dr. Fletcher has agreed to study the recommendations of the Rogers Commission with an open mind and without reservations. That certainly is, in my opinion, the first step in the right direction. A lot of other steps must follow to fully implement the tough changes required by the Commission's findings and recommendations.

The Rogers Commission has made it abundantly clear that a serious, thoughtful, and thorough review of NASA, its policies and practices, is overdue. It is unfortunate that it took a tragic accident and the loss of seven lives to get our undivided attention.

Mr. Chairman, I cannot help but express a deep personal frustration at this time. In the aftermath of the *Challenger* accident, I grew increasingly tired of seeing NASA again and again adopt a defensive attitude, and generally less than cooperative posture toward the inquiry and constructive criticism. However, I believe that Dr. Fletcher has recently committed to changing this attitude, and I welcome this initiative. I hope he is successful in implementing this change at all levels of NASA management. All of us are anxious to get on with the business of rebuilding the space program.

I intend to lend my full support to that effort. There is, however, a string of issues which continues to concern me greatly. I am particularly troubled by NASA's organizational management structure as it applies to the space transportation system, its policies for certifying hardware, and the agency's approach toward criticality one and two items in risk analysis. I'll pursue these issues during the course of our hearings.

Dr. Fletcher, the bad news is that you have your work cut out for you, and it won't be easy. The good news is that I believe you'll have the full support of this committee as you begin the task of fixing the critical problems and to rebuild our space program. Thank you very much.

[The prepared opening statement of Mr. Lujan follows:]

OPENING STATEMENT

BY

HON. MANUEL LUJAN, JR. (R-NM)

RANKING REPUBLICAN MEMBER

COMMITTEE ON SCIENCE AND TECHNOLOGY

NASA'S RESPONSE TO THE ROGERS COMMISSION REPORT

JUNE 11, 1986

MR. CHAIRMAN, I JOIN YOU IN WELCOMING DR. FLETCHER AND THE OTHER NASA WITNESSES WHO COME BEFORE US TODAY. I LOOK FORWARD TO HEARING THEIR INITIAL RESPONSES TO THE CONCLUSIONS AND RECOMMENDATIONS MADE BY THE ROGERS COMMISSION AS THE RESULT OF ITS INVESTIGATION INTO THE CHALLENGER ACCIDENT.

I WAS GLAD TO HEAR THAT DR. FLETCHER HAS ALREADY AGREED TO STUDY THE RECOMMENDATIONS OF THE ROGERS COMMISSION--AND I QUOTE--"WITH AN OPEN MIND AND WITHOUT RESERVATIONS." THAT CERTAINLY IS THE FIRST STEP IN THE RIGHT DIRECTION, BUT MANY OTHER STEPS MUST FOLLOW TO FULLY IMPLEMENT THE TOUGH CHANGES REQUIRED BY THE COMMISSION'S FINDINGS AND RECOMMENDATIONS.

THE ROGERS COMMISSION HAS MADE IT ABUNDANTLY CLEAR THAT A SERIOUS, THOUGHTFUL AND THOROUGH REVIEW OF NASA, ITS POLICIES AND PRACTICES IS LONG OVERDUE. IT IS UNFORTUNATE THAT IT TOOK A TRAGIC ACCIDENT AND THE LOSS OF SEVEN LIVES TO GET OUR SPACE AGENCY'S UNDIVIDED ATTENTION.

MR. CHAIRMAN, I CANNOT HELP BUT EXPRESS A DEEP PERSONAL FRUSTRATION AT THIS TIME. IN THE AFTERMATH OF THE CHALLENGER ACCIDENT, I GREW INCREASINGLY TIRED OF SEEING NASA AGAIN AND AGAIN ADOPT A DEFENSIVE TONE AND A GENERALLY LESS THAN COOPERATIVE POSTURE TOWARDS OPEN INQUIRY AND CONSTRUCTIVE CRITICISM. I BELIEVE THAT DR. FLETCHER HAS RECENTLY COMMITTED TO CHANGING THIS ATTITUDE AND I WELCOME HIS INITIATIVE. I HOPE THAT HE IS SUCCESSFUL IN IMPLEMENTING THIS CHANGE AT ALL LEVELS OF NASA MANAGEMENT. ALL OF US ARE ANXIOUS TO GET ON WITH THE BUSINESS OF REBUILDING THE SPACE PROGRAM.

I INTEND TO LEND MY FULL SUPPORT TO THAT EFFORT. THERE IS, HOWEVER, A STRING OF ISSUES WHICH CONTINUES TO CONCERN ME GREATLY. I AM PARTICULARLY TROUBLED BY NASA'S ORGANIZATIONAL AND MANAGEMENT STRUCTURE AS IT APPLIES TO THE SPACE TRANSPORATION SYSTEM, ITS POLICIES FOR CERTIFYING HARDWARE, AND THE AGENCY'S APPROACH TOWARD CRITICALITY 1 AND 2 ITEMS AND RISK ANALYSIS. I WILL PURSUE THESE ISSUES DURING THE COURSE OF OUR HEARINGS.

DR. FLETCHER, THE BAD NEWS IS THAT YOU HAVE YOUR WORK CUT OUT FOR YOU--AND IT WON'T BE EASY. THE GOOD NEWS IS THAT I BELIEVE YOU WILL HAVE THE FULL SUPPORT OF THIS COMMITTEE AS YOU BEGIN THE TASK OF FIXING THE CRITICAL PROBLEMS TO REBUILD OUR SPACE PROGRAM.

THANK YOU.

Mr. ROE. I thank the distinguished gentlemen.

If there are any other members of the committee that have an opening statement that they want to issue today, please put it in the record.

Mr. VOLKMER. Mr. Chairman, I have a statement I'd like to have inserted in the record at this point.

Mr. ROE. At this point. No objection; so ordered.

[The prepared opening statement of Mr. Volkmer follows:]

STATEMENT BY

HON. HAROLD L. VOLKMER
Chairman, Subcommittee on Investigations
and Oversight

11 June 1986

Mr. Chairman, this is an uncommon and unwanted position we find ourselves in today. We have met many times in this room to welcome back astronaut crews and learn of the work that they have been performing in space. We have watched satellite repairs and orbital construction projects with fascination. Today, we have the sad duty to find out why we cannot extend to the brave crew of Space Shuttle mission 51-L the same privilege.

Mr. William Rogers and the other members of the commission appointed by the President to investigate this tragedy have done a thorough and comprehensive job. I salute them for their dedication and perseverence in tracking down the information necessary for us to understand how this accident occurred and what we will need to do in order to guarantee that our astronauts take no further unnecessary risks.

The Commission's report has raised some serious questions in my mind and I intend to start asking those questions today. I believe the answers will be critical in NASA's effort to redesign the flawed systems identified by the Rogers Commission and to develop a management structure that does not allow the agency to ignore problems of such a critical nature again.

We saw after the Apollo fire in 1967 that NASA is able to accept tough criticism and emerge stronger for it. I have no doubt that the agency's new Associate Administrator for Space Flight, Admiral Truly, will take whatever steps are necessary to assure Congress and the Nation that when the Shutle flies again, it will do so safely.

Mr. ROE. Any others?

Mrs. LLOYD. Mr. Chairman, I have a statement.

Mr. ROE. The gentlelady from Tennessee. No objection; so ordered.

[The prepared opening statement of Mrs. Lloyd follows:]

STATEMENT OF

HON. MARILYN LLOYD

JUNE 11, 1986

MR. CHAIRMAN, THIS HEARING MARKS A NEW BEGINNING FOR NASA AND THE COMMITTEE BECAUSE OF THE IMPACT OF THE CHALLENGER ACCIDENT. WE HEARD FROM THE ROGERS' COMMISSION THAT THE DESIGN OF THE SOLID ROCKET BOOSTER IS POOR AND IT MUST BE FIXED. WE ALSO HEARD THAT THE MANAGEMENT PROCESS WITHIN NASA IS SERIOUSLY FLAWED, AND IT WILL BE THIS COMMITTEE'S RESPONSIBILITY TO SEE THAT THE PROPER FIX IS MADE. I DO NOT THINK THAT WE SHOULD UNDERESTIMATE THE DIFFICULTY SINCE MANY PERCEIVE AN "INSTITUTIONAL HARDENING OF THE ARTERIES" AT NASA HEADQUARTERS AND THE FIELD CENTERS. COMMISSIONER ROGERS TALKED ABOUT CHANGING THE "MIND SET" AMONG MANAGEMENT, AND I AM SURE THAT DR. FLETCHER UNDERSTANDS THAT THAT WILL TAKE A SIGNIFICANT EFFORT ON HIS PART.

I WAS DISTURBED ABOUT THE FACT THAT MANY MEMBERS AND THE ROGERS' COMMISSION FOCUSED SO HEAVILY ON SAFETY INADEQUACIES BECAUSE OF THE TRAGIC CONSEQUENCES OF THE CHALLENGER ACCIDENT. IT SEEMS TO ME THAT

THE ISSUE IS THAT OF A QUALITY PRODUCT AND ACHIEVING A LEVEL OF EXCELLENCE ONCE AGAIN. IF NASA DOES ITS JOB EXCEEDINGLY WELL IN DESIGN AND TESTING AND OTHER ACTIVITIES, SAFETY WILL BE ASSURED. THE ISSUE HERE IS NOT SIMPLY SAFETY -- IT IS NASA'S PRODUCT, AND I AM AFRAID THAT PRIDE AND TECHNICAL ARROGANCE HAVE ALLOWED THE PRODUCT TO ERODE IN QUALITY.

CERTAINLY, IT WILL BE AWKWARD AT FIRST FOR THE COMMITTEE TO MAINTAIN AN ARMS LENGTH WITH THE AGENCY, BUT THAT IS CRITICAL BOTH IN TERMS OF SUBSTANCE AND PERCEPTION. WE CAN NO LONGER BE THE SPACE CADETS OF YESTERYEAR. ALSO, I FOR ONE HAVE NO REGRETS ABOUT SUPPORTING THIS GREAT AGENCY THROUGH ITS MANY TRIUMPHS. LOOKING BACK TO ANOTHER TRAGEDY, THAT OF THE APOLLO 204 FIRE, I THINK WE CAN LEARN FROM BOTH THE SIMILARITIES AND DIFFERENCES. AT THAT TIME, THE SCIENCE COMMITTEE RALLIED TO SUPPORT THE PROGRAM AND CARRIED OUT AN INTENSIVE INVESTIGATION TO IDENTIFY WHAT NEEDED FIXING. HOWEVER, THE POLICY CHOICE WAS A RATHER SIMPLE ONE IN 1967. THAT IS, AT WHAT PACE TO PROCEED WITH THE APOLLO PROGRAM IN THE WAKE OF THE FIRE ACCIDENT. TODAY, DR. FLETCHER AND HIS LIEUTENANTS ARE FACED WITH A COMPLEX SET OF TRADE-OFFS AMONG POLICY ISSUES, AND THE AGENCY IS MUCH MORE CONSTRAINED BY ALLOCATION OF RESOURCES. I, FOR ONE, HAVE AN OPEN MIND

ON THIS DIFFICULT SET OF CHOICES BEFORE US. BUT I WOULD EMPHASIZE THAT THE ACCIDENT HAS MADE THE NASA BUDGET A WHOLE NEW BALLGAME FOR THIS COMMITTEE. I DO NOT BELIEVE THAT THERE ARE ANY SACRED COWS IN TERMS OF PREVIOUS COMMITTEE POSITIONS ON SPACE COMMERCIALIZATION, SHUTTLE-DERIVED VEHICLES, ORBITER REPLACEMENTS, ETC. IT SEEMS TO ME THAT ONE COMMITTEE POSITION THAT SHOULD CARRY OVER TO THE NEXT CONGRESS IS THAT WE MUST DO RESPONSIBLE OVERSIGHT AND SATISFY OURSELVES INDEPENDENTLY THAT NASA IS ON THE RIGHT TRACK INSTITUTIONALLY. I HAVE AN OPEN MIND ON THE PROGRAMMATIC FUNDING ISSUES, BUT I WILL NOT SUPPORT ANY DECISION WHICH LOOKS LIKE IT IS AIMED AT A QUICK FIX. THE IMPORTANT THING IS TO MAINTAIN THE BEST PEOPLE IN THE AGENCY, ENCOURAGE THEM TO PROVIDE A QUALITY PRODUCT, AND SAFETY WILL BE TAKEN CARE OF.

MR. CHAIRMAN, I LOOK FORWARD TO THIS NEW BEGINNING AND EXPECT TO WORK CONSTRUCTIVELY WITH NASA TO RECAPTURE THOSE GOLDEN DAYS OF SUCCESS. MY HOPES AND PRAYERS GO WITH DR. FLETCHER AND HIS TEAM.

Mr. ROE. The gentleman from New York. No objection; so ordered. In fact, everybody, no objection; we'll put them in at this time, and that will solve that problem.

[The prepared opening statements of other members follow:]

GEORGE E. BROWN, JR.

STATEMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

REVIEW OF THE REPORT OF THE

ROGERS COMMISSION ON THE

CHALLENGER ACCIDENT

JUNE 11, 1986

Mr. Chairman, I would like to welcome Dr. James Fletcher and other representatives of NASA to this Committee hearing in the spirit of sober discussion. Today, and in the days that follow, we will review and evaluate the findings and recommendations of the Presidential Commission on the Challenger Accident. The Commission, commendably chaired by William P. Rogers, has presented a thorough and comprehensive document. Based on the Rogers Commission report, Congress will be able to make vital decisions on how to proceed with the future of the space program.

I look forward to the conclusion of these hearing--to when we can put the accident behind us so NASA can get on with the work that it had been doing for nearly three decades. I am confident that NASA will make the fixes in both system design and operating procedures that are necessary to resume shuttle flights. It is a matter of national importance that we carry on with a vigorous space program.

As we begin our evaluation of NASA's technical and managerial practices associated with the Challenger accident, we should recognize that fault for the shuttle disaster does not lie solely with NASA. Congress and the Executive Branch also deserves criticism. As much as anything else, the problems at NASA are a product of our flawed oversight. In the past two decades, we have sent NASA on a budgetary roller coaster ride which tested the limits of its highly complex infrastructure. Congress and the Administration made ambitious demands on NASA, without always being forthcoming with adequate funding.

This Committee, in particular, has perhaps been overly cordial to NASA in the past. This cozy relationship does not serve the interest of NASA or the American people. Clearly, some distancing between this Committee and NASA will occur. From now on NASA must be prepared to undergo the same scrutiny as any other federal government agency.

The U.S. space policy is a patchwork quilt of space projects, with the Space Shuttle being the center-piece. Although these programs are individually meritorious, there exists no overall goal. We approve NASA budget year after year without a clear vision of what the ulitmate goal in space should be. I believe NASA has suffered for lack of a comprehensive national space policy, and to some extent this contributed to the Challenger disaster.

We need the leadership to establish a set of long-term goals in space which will guide NASA. If we have a set of long-term objectives to work toward, then Congress and the President can make intelligent decisions on the interim steps for getting there. I bring to my colleagues attention the recently released report by the National Commission on Space which outlines a set of ambitious goals worthy of serious consideration. I believe that the recommendations of this Commission, headed by Thomas Paine, can be used as the basis for a truly comprehensive National Space Policy.

Mr. Chairman, we have a difficult job ahead of us as we conduct these hearing and prepare our own report. This Committee must be decisively critical of NASA, yet leave room for encouragement so we can move forward. On the one hand, we must not be timid about asking embarrassing or uncomfortable questions. On the other hand, we must not damage the essence of the space program and foster the dedicated continuation of our nation's noblest venture. With the talent that exists on this Committee, I know we can strike a balance between ciriticism and encouragement of NASA.

OPENING REMARKS OF

REPRESENTATIVE ROBERT S. WALKER
RANKING REPUBLICAN MEMBER
SUBCOMMITTEE ON SPACE SCIENCE
AND APPLICATIONS
U.S. HOUSE OF REPRESENTATIVES

JUNE 11, 1986

Good morning, Mr. Chairman. Today marks a major step in our recovery for the tragic loss of Challenger and her gallant crew.

Today we will begin the process of reviewing the accident and the recommendations of the Rogers Commission with the management of NASA. I suspect that we have a very rocky road to traverse this morning, and, perhaps, for many days to come.

This committee has been accused by the media of not being sufficiently critical of NASA in the past. In many ways that is unfair. But, there is some truth to the claim. I suspect that most other members of the committee would agree with me that in the future we will no longer serve as cheerleaders for NASA, but from here on out we will actually be in the huddle with them.

Yesterday we heard from the Rogers Commission and they brought forth an indictment of the agency. There are a number of areas which this committee needs to look into before we even consider returning to flight status. I am particularly concerned about the lack of a functioning safety system within NASA. The Rogers Commission refers to it as a "silent safety system." My own view is that it is non-existant. This is an area which must be addressed by the Administrator and the highest levels of NASA management.

I am also deeply concerned that the agency continues to keep people who played key roles in the multiple management failures which led to the accident in key management roles in the manned space program. I am not looking for scapegoats, and I do not want to see a witch hunt. However, I have lost confidence in those who were repeatedly told of the problems with the o-rings, and who neither solved the problem themselves, nor took it to their superiors.

We are told that the top managers would not have launched if they had been aware of the concern at lower levels, but they were unaware of the problem. I think that it is essential to keep those people who were responsible for the data not reaching to top out of the management of the manned program in the future.

I think we also must find out why the Congress was never told of the problems that the Rogers Commission has uncovered. We cannot approve of a return to flight status until all of the questions that the commission raised have been fully answered to our satisfaction.

Mr. ROE. Now, for the benefit of the members of the committee, we have planned on working with Dr. Fletcher and Admiral Truly and the members of their team as I announced before. During the day, today, and tomorrow there will be ample time to develop the issues involved and to get the facts before the committee as we unfold the second phase of our examination, which really has to do with not only what happened—which we had from the testimony yesterday—but what is the observations and the findings and the references that will be developed by the NASA leadership and management under Dr. Fletcher.

Dr. Fletcher has to visit with the President; they've got a program that's laid on this morning—I think it's around 11 a.m., if I'm not mistaken—but as he concludes that program, he'll be back here thereafter to continue on through the afternoon. So again, for the benefit of the members, there will be ample time. We'll go through the 5-minute process to get organized and get started. So as you are developing your areas of interest, I think you ought to develop them in continuity so that we are carrying through any particular issue in a continuity so it makes sense as far as the record is concerned and as far as getting the work done.

Now, having said that, I want to welcome our full committee chairman, Hon. Don Fuqua from Florida. Don, is there any comment you want to make before we begin?

Mr. FUQUA. Well, thank you, Mr. Chairman. I just want to welcome Dr. Fletcher back. I think he's not been before this committee in this capacity in about 9 years.

Welcome back, Dr. Fletcher, and we look forward to working with you.

Mr. ROE. All right. Having said that, Dr. Fletcher, again we want to welcome you and Admiral Truly and your team. If you would go ahead—I know you have your formal statements, but I do think that they're of such sufficiency that we should review the entire full statements, so to set the framework for today's hearings. So, Dr. Fletcher, if you would proceed, I'd appreciate it.

STATEMENT OF DR. JAMES C. FLETCHER, ADMINISTRATOR, NASA

Dr. FLETCHER. Thank you, Mr. Chairman, members of the committee. I welcome this opportunity to appear before you to address the Rogers Commission report; not because it's easy, or pleasant for me, or for NASA, but because it is a necessary and appropriate step in a democratic society.

The *Challenger* accident, in full sight of the American people and the world, raised many questions about what we, as an agency, were doing, and certainly, how we were doing it. After a long period of many successes, we at NASA are brought back to Earth, both literally and figuratively, for a time of reassessment.

Mr. Chairman, the American people seek answers and you, as its elected representatives of this committee, do, too. We are prepared today to begin to give you our best current information, plans, and responses to questions and recommendations. We do not have all the answers yet, and we expect our dialog with you to continue often during the coming months. We are dealing with very complicated problems. Simple answers, quick and easy answers are just not honest or reasonable. The Commission report urges me, as NASA Administrator, to report to the President 1 year from now on our progress. I intend that both you and he have interim reports as we work to reclaim the excellence that has been our hallmark.

I said last Monday that NASA was prepared to study the Rogers Commission report with an open mind and without reservations, and that is absolutely true. I said that we had already been at work—indeed, had begun to seek answers to the disaster—even before the Commission was appointed, and that is also true. And I promised that where NASA management was found to be weak, we would strengthen it; where engineering or design or process needed improvement or change, we would do what was needed; and where our internal communications—and that includes decisionmaking—were poor, they would be made better.

It seemed to me that the Rogers Commission report not only was painstaking as it looked back, but cleared the air in a sense for us to move on. The Rogers Commission, in short, not only analyzed the failure of the *Challenger* launch and made recommendations for change, it also reaffirmed our goal.

Mr. Rogers, in his letter of transmittal to the President, said, "The Nation's task now to move ahead to return to safe space flight and to its recognized position of leadership in space, there could be no more fitting tribute to the *Challenger* crew than to do so."

We intend to do so. No tribute may be sufficiently worthy, considering the sacrifice of the *Challenger* crew; but we shall do all we can to make space flight safe and to maintain American leadership in space.

Mr. Chairman, that is not an idle statement, and I would like to review briefly why I believe that is so.

First, I believe this body will take an active role in redefining our national space effort for the decade ahead and into the next century, continuing a role this committee has had from the beginning of the American space program.

Second, NASA, virtually from the moment of the accident, has been deeply involved in finding out what went wrong so that we could plan for a safer future.

Third, the Rogers Commission has performed in an exceptional way, without posturing, without placing blame in a vindictive manner, without seeking to destroy a program that has brought knowledge, pride, and glory to this Nation.

Let me begin with NASA's relationship with Congress. There are those who have seized on our mistakes to question your oversight, the legitimacy of longtime cooperation and, indeed, possibly the space program itself. The fact is, Mr. Chairman, that Congress has always maintained a careful and thoughtful balance between a critical and sometimes skeptical view of space plans, even as it supplied support and encouragement when that seemed justified.

In the 1960's, getting to the Moon was a national policy; and with the American people's hearty endorsement, the Congress responded with program and financial support to match the public's almost unlimited enthusiasm. But those days are long gone. What has remained is a close working relationship and, I hope, mutual respect. I intend to maintain and improve both. I intend, with Congress, to look carefully at our programs; and, with OMB, to make sure that every request to you is a responsible one. We will set priorities with full disclosure and discussion, and we will carefully spend the moneys that you authorize.

The American people have a nonpartisan pride in the accomplishments of the space program and in American preeminence in this field. I do not believe they want a timid program that doesn't maintain leadership. I do believe they want this committee and NASA to move with assurance together in seeking new goals.

Let me now review some of NASA's own activities in the weeks since the *Challenger* accident shook our confidence. We were forced to look at everything we had done, from design to the process of our decisionmaking. Part of this was the responsibility of a task force under Admiral Truly's leadership and with day-to-day direction by his associate, J.R. Thompson. It involved a development and production team, a prelaunch activity team, a mission planning and operations team, an accident analysis team, a salvage support team, and a photo and TV team. Much of its activity was aimed at helping the Rogers Commission. The NASA task force reports were made to the Commission in mid-April; the data is still being gathered, analyzed, and pursued by appropriate NASA leaders.

I also asked Gen. Sam Phillips, who was Apollo Program Director when we were on our way to the Moon, to study every aspect of how NASA manages its programs, including relationships between our various space centers, with each other, and with NASA Headquarters. General Phillips' review is not limited to the *Challenger* accident, and operates with broad authority from me to question every aspect of our activities. The review and report to me is being done without a deadline and will probably take the rest of this year for completion; but, as I become aware of things that need to be done, they will be implemented at that time.

The period from the *Challenger* accident until our next launch will be a time of reevaluation for NASA. Our work will not stop; it will only be more intense than ever.

Mr. Chairman, during the past several weeks—and particularly during the past several days—the question of when we will fly a space shuttle has been raised. I have said that our target date is July 1987; but I want that goal placed in its proper context, and that context is safety. We will fly in 1987 if it is safe to do so. We will not fly if it is not. In the complicated, interrelated situation in which we must function, a target date is necessary, particularly to potential users. But the date is not a fixed and inflexible one.

We are realistic about our problems, some of which the Rogers Commission noted, and we know there may be delays in design, testing, and manufacturing. You will hear more about all of that from Admiral Truly in a moment. For the moment, we keep the date of summer of 1987 as a goal which may change; what is not changeable is our commitment to fly again only when it is safe to do so. We will fly when we know clearly that we have dealt with the problems which led to the *Challenger* disaster.

Finally, while Admiral Truly will deal with the specific recommendations of the Rogers Commission report and what we are already doing or have done, I want to make several observations about the report itself.

I said on Monday that the report of a Presidentially appointed independent body carries with it special status and the compelling obligation to study its conclusions with an openness and willingness to change. That is particularly so with this report. It was done thoroughly and with care, with both toughness and understanding, and—I repeat—it was done with our cooperation. In its preface, it was noted that NASA established several teams of people, not involved in the *Challenger* launch process, to support the Commission and its panels.

I think it is important for the committee, the House, and the American people to understand that NASA and the Rogers Commission have worked closely together, even as each maintained its independence during the many weeks of the Commission's work. The preface of the report said, "These NASA teams have cooperated with the Commission in every aspect of its work. The result has been a comprehensive and complete investigation. That investigation will have profound effects on NASA and the space programs of the United States. Changes have already been made; more will come. Yet, Mr. Rogers said, "you don't want to punish; you just want to make sure it doesn't happen again." That is the goal, I think, we all share. That is certainly NASA's goal, beyond question.

I have said, speaking for the employees of an agency that has given this world not only lasting knowledge and moments of excitement and joy, that we have reached, with the Rogers Commission report, a day of resolve, a time of beginning, a time of rededication. I think you will see the truth of that in Admiral Truly's testimony that will follow.

After Admiral Truly's statement, we will be pleased to respond to any questions the committee may have.

Thank you.

[The prepared statement of Dr. Fletcher follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

JUNE 11, 1986

Statement of

Dr. James C. Fletcher
Administrator

National Aeronautics and Space Administration

before the

Committee on Science and Technology
United States House of Representatives

Mr. Chairman and Distinguished Members of the Committee:

I welcome this opportunity to appear before you to address the Rogers Commission Report, not because it is easy or pleasant for me or for NASA, but because it is a necessary and appropriate step in a democratic society.

The Challenger accident, in full sight of American people and the world, raised many questions about what we as an agency were doing and certainly how we were doing it. After a long period of many successes, we at NASA are brought back to Earth, both literally and figuratively, for a time of reassessment.

The American people seek answers and you, as its elected representatives, do, too. We are prepared today to begin to give you our best current information, plans and responses to questions and recommendations. We do not have all the answers yet and we expect our dialogue with you to continue often during the coming year.

We are dealing with very complicated problems. Simple answers... quick and easy answers ...are just not honest or reasonable. The Commission report urges me, as NASA Administrator, to report to the President one year from now on our progress. I intend that both you and he have interim reports as we work to reclaim the excellence that has been our hallmark.

I said on Monday that NASA was prepared to study the Rogers Commission's report with an open mind and without reservations and that is absolutely true.

I said that we had already been at work; indeed, had begun to seek answers to the disaster even before the Commission was appointed, much less had a chance to study, question, conclude, and report to the President. And that is also true.

And I promised that where NASA management was found to be weak, we would strengthen it; where engineering or design or process needed improvement or change, we would do what was needed; and that where our internal communications, and that includes decision-making, were poor, they would be made better.

It seemed to me that the Rogers Commission Report not only was painstaking as it looked back, but cleared the air, in a sense, for us to move on.

The Rogers Commission, in short, not only analyzed the failure of the Challenger launch and made recommendations for change, it also reaffirmed our goal. Mr. Rogers, in his letter of transmittal to the President, said, "The nation's task now is to move ahead to return to safe space flight and to its recognized position of leadership in space. There could be no more fitting tribute to the Challenger crew than to do so."

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In the sixties, getting to the Moon was a national policy and with the American people's assent, the Congress responded with program and financial support to match the public's almost unlimited enthusiasm. But those days are long gone.

What has remained is a close working relationship and, I hope, mutual respect. I intend to maintain and improve both. I intend with Congress to look carefully at our programs and with OMB to make sure that every request to you is a responsible one. We will set priorities with full disclosure and discussion and we will carefully spend the monies you authorize.

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Part of this was the responsibility of a task force under Admiral Truly's leadership and with day-to day direction by his associate, J.R. Thompson. It involved a development and production team, a prelaunch activity team, a mission planning and operations team, an accident analysis team, a salvage support team, and a photo and TV team.

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General Phillips' review is not limited to the Challenger accident and operates with broad authority, from me, to question every aspect of our activities. The review and report to me is being done without a deadline and will probably take the rest of this year for completion but as I become aware of things that need to be done they will be implemented at the time.

The period from the Challenger accident to our next launch will be a time for re-evaluation for NASA. Our work will not stop. It will only be more intense than ever.

Mr. Chairman, during the past several weeks and particularly during the past few days, the question of when we will next fly a space shuttle has been raised. I have said that our target date is July 1987, but I want that goal placed in its proper context and that context is safety.

We will fly in 1987 if it is safe to do so. We will not fly if it is not. In the complicated, inter-related situation in which we must function, a target date is useful, particularly to potential users. But the date is not a fixed and inflexible one.

We are realistic about our problems -- some of which the Rogers Commission noted -- and we know there may be delays in design, testing and manufacture. You will hear more about all of that from Admiral Truly.

For the moment, we keep the date as a goal which may change. What is not changeable is our commitment to fly again only when it is as safe to do so as we can make it. We will fly when we know clearly that we have dealt with the problems which led to the Challenger disaster.

Finally, while Admiral Truly will deal with the specific recommendations of the Rogers Commission Report and what we are already doing or have done, I want to make several observations about the Report.

I said on Monday that the report of a Presidentially appointed, independent body carries with it special status and the compelling obligation to study its conclusions with an openness and willingness to change.

That is particularly so with this Report. It was done with care and thoroughly, with both toughness and understanding. And, I repeat, it was done with our cooperation. In its Preface, it was noted that NASA established several teams of people not involved in the Challenger launch process to support the Commission and its panels.

I think it is important for the Committee, the House, and the American public to understand that NASA and the Rogers Commission have worked closely together, even as each maintained its independence, during the many weeks of the Commission's work.

The preface said, "These NASA teams have cooperated with the Commission in every aspect of its work. The result has been a comprehensive and complete investigation." That investigation will have profound effects on NASA and the space programs of the United States. Changes have already been made. More will come.

Yet, Mr. Rogers said, "You don't want to punish. You just want to make sure it doesn't happen again."

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I think you will see the truth of that in Admiral Truly's testimony that will follow. After Admiral Truly's statement I would be pleased to respond to any questions which the Committee may have.

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Mr. ROE. I thank you, Dr. Fletcher.

Admiral Truly, would you go ahead with your formal testimony, please?

STATEMENT OF REAR ADM. RICHARD TRULY, U.S. NAVY, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, NASA

Admiral TRULY. Mr. Chairman and distinguished members, during the months since our return to duty with NASA following the tragic loss of *Challenger,* I, along with my entire organization, have spent many hours in support of the Rogers Commission. We have done our best to assist them in the conduct of their investigation, and I have reviewed the Commission's report to the President.

I personally found it to be extremely thorough and comprehensive. I am in general agreement with all of the findings and all of the recommendations, and I am pleased to say that because of our close association with Chairman Rogers and their work, I've been able to anticipate the corrective actions required to safely return the space shuttle to flight.

These actions were initiated by my memorandum of March 24, 1986, and a subsequent one by Mr. Arnie Aldrich on March 28, which directed the shuttle program to undertake this task.

I would like to now briefly take each of the Commission's recommendations and provide you with a summary status of my work.

The first recommendation of the Commission had to do with the design of the faulty solid rocket motor joint. On March 24, I directed the Marshall Space Flight Center to form a SRM redesign team. The team was to include participation not only from Marshall, but from other NASA centers, as well as individuals outside of NASA. It is headed by Mr. John Thomas as its leader; it includes personnel from the Johnson Space Center, the Kennedy Space Center, the Langley Research Center, and the Astronaut Office; and, in addition, has an expert advisory panel of 12 people, half of whom are from industry.

As a result of the early suggestion from the Commission, Dr. Fletcher has requested the National Research Council to appoint an independent oversight committee to review the activities of our redesign team. The National Research Council has agreed, and the members of that committee have recently been announced.

The team is pursuing a number of options for the redesign of the joint, and we intend to have a preliminary design review later this summer. Let me assure you that safety, and not schedule, is and will continue to be our primary concern. We will not return to flight status without a safe, tested, and certified design. I welcome the assistance of the oversight committee and I intend to work very closely with them, just as I did with the Rogers Commission, to assure full and complete consideration of all of their recommendations.

The second of the major recommendations of the Rogers Commission has to do with shuttle management. In that same memorandum of March 24, I initiated a detailed review of our management structure to determine those changes, both technically and philosophically, that are required. I wholeheartedly support the recommendations to reassess and define the responsibilities of the STS program manager, and to ensure that he has the specific type of authority that the Commission recommends in their report. I intend to reevaluate the shuttle's level I, level II, and level III management structure, and to implement any changes that are necessary to strengthen that structure and to reduce the potential for conflict between the program organization and the institution, whether it be at headquarters or at our field centers.

Another recommendation had to do with the utilization of present and former members of the Astronaut Office, and we will give that proper consideration for management positions within the Agency.

I want to tell you that I concur completely with the concept of a shuttle safety panel reporting to me, and I will initiate action to implement this concept and I will leave my door open to them at all times.

As you know, Dr. Fletcher has mentioned that he has asked General Phillips to review all aspects of NASA program management, and this internal shuttle review will be done in coordination with General Phillips.

The third recommendation of the report has to do with the criticality review and hazard analysis. Again, in March, Mr. Aldrich—who is the level II program manager of the space shuttle system—initiated a thorough review of all items on the critical items list. As the first step in that review, every criticality and criticality 1-R item waiver was canceled, and NASA is in the process of a complete review of every one of those items—not just the solid rocket motor joint—and if we find those that are not revalidated by this review, they will be redesigned and fixed and recertified prior to flight. Further, the criticality 2 and 3 items are being reviewed to make sure that they are properly categorized. So this, again, by understanding what the Commission was doing, we got almost a 3-month head start on getting going again.

The fourth major recommendation has to do with NASA's safety organization. And although safety, reliability, and quality assurance is not my personal responsibility within the agency, I am vitally concerned about this activity and I pledge to work closely and do what I can to strengthen this most important element of our program.

The shuttle program does perform many of the activities that relate to program safety, and all of these are under our review. Each person in the Agency has an obligation to put safety first, and this will be reiterated many times over the next month. I intend to ensure that the management structure and its system is modified so that reporting requirements are clearly defined and rigidly enforced, and management at all levels is informed of all significant issues and their status.

The fifth major recommendation has to do with improved communications within our system. I personally think that this recommendation may be the most important work of the Presidential Commission. It applies not to one part of our system, but to all of our people and their organizations. As a part of our review, both internal and external communication will be given a primary consideration. This activity will include the Marshall Space Flight Center and all of the other shuttle program organizations and centers, and will ensure that the specific recommendations of the Commission will be considered.

Mr. Chairman, I would like to depart just for a moment from my prepared statement and tell you that of all the recommendations in the Commission's report, the two that I had not formally moved out on—and purposely so—until the report was in our hands had to do with the assessment of program management and communication. But now that we have that report, I feel that it is time to move out.

I have asked Capt. Bob Crippen, who has completed his work at the Kennedy Space Center as a full-time member of our task force since the *Challenger* accident, to head a small group which will examine the overall shuttle program management and report to me. Where changes to existing organization or lines of authority are deemed appropriate, this group will recommend solutions and options to myself and Dr. Fletcher.

Mr. ROE. Would the gentleman hold at that point? I think it would be profitable, because we have a continuity I don't want to lose——

Admiral TRULY. Yes, sir.

Mr. ROE [continuing]. And I see we've been called to the floor, so why don't the Members take the next 10 minutes. We'll recess, go to the floor and vote, and please return as quickly as possible because we are going to continue our work within 10 minutes.

And I want to keep your continuity going.

Admiral TRULY. Yes, sir.

Mr. ROE. I think you'll have to reiterate this part so that it's clear what you're trying to report.

Admiral TRULY. Yes, sir.

Mr. ROE. We'll recess for 10 minutes to vote and then return.

[Recess.]

Mr. ROE. The committee will come to attention and reconvene.

When we broke up for the vote we were hearing from Admiral Truly, and you were adding some added information in reference to the communications methodology and management. So maybe it would be best if you recap that for us again——

Admiral TRULY. Yes, sir.

Mr. ROE [continuing]. So we don't lose the continuity.

Admiral TRULY. Thank you, Mr. Chairman.

As I was saying, there are two recommendations in the Commission's report—the fifth recommendation, which has to do with improved communication, and the second recommendation, which is the program management structure review that I elected not to take a firm action on until we had the Commission report in our hands so the action would be appropriate. As I mentioned, Capt. Bob Crippen, who has been stationed at the cape since the accident and has been a part of the task force, is being called to headquarters for a period of time to head a small group which will examine the overall shuttle program management. Where changes to our existing organizational lines of authority are deemed appropriate, this group will recommend solutions for approval.

I'd like to quote from my memorandum on this subject from March 24:

The National Space Transportation Program management, philosophy, structure, reporting channels, and decisionmaking process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit-to-launch process.

Captain Crippen's group will review the findings and conclusions of the Rogers Commission; as a matter of fact, that's the first chore that they will have to do, is to go through this entire report with a fine-toothed comb.

Mr. ROE. Are you reading from that memorandum now, Admiral Truly?

Admiral TRULY. No, sir.

Mr. ROE. Or just referring to it?

Admiral TRULY. No, sir; just referring to it.

Mr. ROE. All right. Well, why don't we move to make that a part of the record at this point? If there is no objection, so ordered.

Admiral TRULY. Thank you, sir.

[Material referred to follows:]

NASA

National Aeronautics and
Space Administration
Washington, D.C.
20546

Reply to Attn of M

MAR 24 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- o ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- o FIRST FLIGHT/FIRST YEAR OPERATIONS
- o DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

<u>ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:</u>

<u>Reassess Entire Program Management Structure and Operation</u>

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

25th Anniversary
1958-1983

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/ operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- daylight KSC launch
- conservative flight design to minimize TAL exposure
- repeat payload (not a new payload class)
- no waiver on landing weight
- conservative launch/launch abort/landing weather
- NASA-only flight crew
- engine thrust within the experience base
- no active ascent/entry DTO's
- conservative mission rules
- early, stable flight plan with supporting flight software and training load
- daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

Mr. ROE. The gentleman will proceed.

Admiral TRULY. Captain Crippen's group will be a small one, and he will visit with people inside and outside of the shuttle program, including former NASA managers such as former Associate Administrators, Center Directors, and people entirely outside of NASA.

After discussing this at some length with Dr. Fletcher, I think that Crip is an ideal choice for this assignment. He's the commander of four space shuttle flights; he's had extensive experience in several NASA programs, including the shuttle, and I look forward to having him to give me a hand in this most critical area. If I could introduce Crip to your committee, I would appreciate the opportunity to do so.

To return to the specific recommendations of the Rogers Commission, the sixth recommendation has to do with landing safety, which I have been involved with for quite a while because landing safety has been a significant concern of our program since the 1970's during the approach and landing tests which I flew, using the space shuttle *Enterprise*. We're going to review all of the shuttle hardware and systems in design reviews to ensure compliance with specifications in our concern for safety. Tires, brakes, and nosewheel systems are included in this activity, and I want to tell you that funding for new carbon brakes has already been approved by me. Tire and brake testing is continuing and scheduled for this summer. KSC runway surface testing has been underway for some time prior to the accident, and is continuing. We're looking at better methods of weather forecasting and weather-related support for the Kennedy complex specifically; and, as you know, the potential for increased landings at Edwards Air Force Base was recognized prior to the accident. Frankly, that will be a dominant factor in our schedule as we return to flight status. We are also going to look very hard at the need for a dual ferry capability for the system, and we will consider that and decide when to come forward to you for your support.

The seventh major recommendation has to do with launch abort and crew escape. As the Commission noted in its report, crew escape was not possible in the 51-L accident. It has been looked at numerous times in the past; nevertheless, prior to the report being issued, we have started—or Arnie Aldrich in Houston—has started a comprehensive crew egress and escape review.

We are looking at our capabilities of escape throughout launch and of the landing environment, and we are relooking at all those possibilities that we've looked at before. We are going to continue to do that. The study is already in progress, and we're looking further at things such as launch commit criteria, flight rules, range safety systems, runway configurations and lengths, and all those complex things that go into the equation.

The bottom line is, we are re-reviewing and we desperately want to provide the best possible margin of safety for our vehicle and our crew.

The eighth recommendation of the Rogers Commission has to do with flight rate. We've already taken some action on this. We are participating with other governmental agencies in a comprehensive review of our Nation's ability to assure access to space.

I want you to know that I personally concur with the mixed fleet concept to avoid reliance on a single vehicle for our Nation. Development of a NASA flight rate which maximizes safety dictates that we fly at a rate consistent with our resources, and I intend to develop a schedule that achieves such a rate.

Within my office is the responsibility for payload assignment and for manifesting, and I can assure you that our manifesting procedures that are noted in the Commission's report—for example, late changes, et cetera, that require additional work in our mission planning organization—are under my personal review, and I intend to change those procedures if they are required to be changed, but more importantly, assure that we have the discipline to reduce the late changes which cause such an upheaval in the flight planning process.

The ninth and final major recommendation of the Commission's report has to do with maintenance safeguards. We are reviewing our maintenance philosophy and its implementation, particularly with regard to our spares inventory. This has been under review since shortly following the accident, and I want to tell you that the results of this activity will be combined with the results of our safety, reliability, and quality assurance review to make sure that we have an overall plan for vehicle processing and maintenance, trend analysis using flight data, good structural inspections, and adequate spare parts.

Mr. Chairman, I came to this job in the weeks following this tragic accident with the resolve and the duty to assist the Presidential Commission in finding the cause. The Commission has done their work; I embrace their report and believe I have set into motion the initial steps to return the space shuttle to safe and effective flight. Their report is a road map for me, and I intend to use it as my mandate for action.

Thank you very much for the opportunity to testify before your committee today, for NASA needs your support and guidance as our Nation returns to space flight.

Thank you, sir.

[The prepared statement of Admiral Truly follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

June 11, 1986

Statement of

RADM. Richard H. Truly

Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Committee:

During the months since I returned to duty with NASA following the tragic loss of Challenger, I, along with my entire organization, have spent many hours in support of the Rogers Commission. We have done our best to assist them in the conduct of their investigation, and I have reviewed the Commission report to the President. I find it to be extremely thorough and comprehensive. I am in general agreement with all findings and recommendations and am pleased to say that because of our close association with their work, I have been able to anticipate the corrective actions required to safely return the Space Shuttle to flight. These corrective actions were initiated by my memorandum of March 24, 1986, and a subsequent memorandum by Mr. Aldrich on March 28, 1986, which directed the Shuttle program to undertake this task. These memoranda are included as enclosures to this statement. I would now like to briefly take each of the Commission's recommendations, and provide you with a summary status of my work.

SOLID ROCKET MOTOR (SRM) DESIGN

On March 24, I directed Marshall Space Flight Center (MSFC) to form a SRM joint redesign team to include participation from MSFC and other NASA centers as well as individuals from outside NASA. This team was formed with Mr. John Thomas as its leader. The team includes personnel from JSC, KSC, LaRC, industry, and the astronaut office. In addition, an expert advisory panel was appointed to assist the redesign team. This panel includes 12 people of whom half are from industry. As a result of an early suggestion from the Commission, Dr. Fletcher requested the National Research Council (NRC) to appoint an independent oversight committee to review the activities of the redesign team. The NRC has agreed and the members of the committee have recently been announced.

The redesign team is currently pursuing several options for redesign of the joint with a tentative date for the Preliminary Design Review this summer. Let me assure you that safety, not schedule, is and will continue to be our primary concern. We will not return to flight status without a safe, tested and certified design. We welcome the assistance of the NRC oversight committee, and I intend to work very closely with them, just as I did with the Rogers Commission, to assure full and complete consideration of their recommendations.

SHUTTLE MANAGEMENT STRUCTURE

The Presidential Commission recommended a thorough review of the Shuttle program structure. On March 24, I initiated detailed review of the NSTS management structure to determine those changes both technically and philosophically that are necessary in order to make the STS a more effective organization. I wholeheartedly support the recommendations to reassess and redefine the responsibilities of the STS Program Manager and to ensure that he has the specific type of authority suggested in the commission report. I intend to reevaluate the Level I/II/III program management concept and to implement any changes necessary to strengthen that structure and to reduce the potential for conflict between the program organization and the institution both at Headquarters and in the field. Utilization of present and former members of the astronaut office will be given proper consideration in that process. I concur completely in the concept of a Shuttle Safety Panel reporting to me and will initiate action to implement this concept and personally leave my door open to them as we move forward.

As you know, Dr. Fletcher has asked General Phillips to review all aspects of NASA program management and this internal Shuttle overview will be accomplished in close coordination with General Phillips.

CRITICAL ITEMS REVIEW AND HAZARD ANALYSIS

In response to my direction, on March 28 Mr. Aldrich initiated a review of all items on the Critical Items List. As a first step, all CRIT 1 and 1R item waivers were cancelled and NASA is in the process of a complete review and reevaluation activity for all items on the list. Those CRIT 1 and 1R items which are not revalidated by the review must be redesigned, certified, and qualified for flight. All other CRIT 2 and 3 items are being reviewed to ensure proper categorization. This review has been under way for some time.

SAFETY ORGANIZATION

Although Safety, Reliability, and Quality Assurance (S,R& QA) is not my direct responsibility, I am vitally concerned about this activity and pledge to work closely and do what I can to strengthen this most important element of our program. The NSTS program does perform many of the activities that relate to program safety and all are under thorough review at this time. Each person in the agency has an obligation to put safety first and this will be reiterated many times over the next months. Within the STS program I intend to ensure that the management structure and its system is modified so that reporting requirements are clearly defined and rigidly enforced, and management at all levels is informed of all significant issues and their current status.

IMPROVED COMMUNICATIONS

I think this may be the most important part of the Commission's work, and that it applies to all our people and organizations. As part of my overall review and restructuring of the management system for the STS, internal and external communication will be given primary consideration. This activity will include MSFC and all other shuttle program organizations and will ensure that the specific recommendations of the Commission will be considered.

LANDING SAFETY

Landing safety has been a significant concern of the program from the days of our approach and landing tests of the "ENTERPRISE." All shuttle hardware and systems are undergoing design reviews to insure compliance with the specifications and concern for safety. The tire, brakes, and nose wheel steering systems are included in this activity, and funding for a new carbon brakes system has been approved. Specifically tire and brake testing is currently scheduled for this summer. KSC runway surface testing had been underway for sometime prior to the accident and is continuing. Better methods of weather forecasting and weather related support are being evaluated at this time. The potential for increased landings at Edwards Air Force Base was recognized prior to the accident and will be a dominant factor in our schedule as we return to flight status. Dual ferry capability has been a desire for some time and will be thoroughly considered during the upcoming months.

LAUNCH ABORT AND CREW ESCAPE

On April 7, Mr. Aldrich initiated a STS Crew Egress and Escape review. The scope of this analysis includes egress and escape capabilities from launch through landing and will provide analyses, concepts, feasibility assessments, cost and schedules for pad abort, bailout, ejection systems, water landings, and powered flight separation. In conjunction with this activity we are also reviewing all launch and launch abort rules and philosophy to ensure that launch commit criteria, flight rules, range safety systems and procedures, landing aids, runway configurations and lengths, performance versus abort exposure, abort and end of mission landing weights, runway surfaces, and other landing related capabilities provide the proper margin of safety to the vehicle and crew.

FLIGHT RATE

NASA is actively participating with other governmental agencies in a comprehensive review of the nations ability to assure access to space. I concur with the mixed fleet concept to avoid reliance on a single vehicle. Development of a NASA flight rate which maximizes safety dictates that we fly at a rate consistent with our resources and I intend to develop a schedule which achieves such a rate. Our payload assignment policy and flight manifesting are under my personal review, to assure both that our rules are clear and that we have the discipline to reduce the late changes which cause such an upheaval in the flight planning process.

MAINTENANCE SAFEGUARDS

The STS maintenance philosophy and its implementation, particularly with regard to our spares inventory, is currently under review since shortly following the accident. The results of this activity will be integrated with the results of our S, R, & QA review to develop an overall plan for vehicle processing, maintenance, trend analysis, structural inspections, and spare parts.

Mr. Chairman, I came to this job in the weeks following this tragic accident with the resolve and duty to assist the Presidential Commission in finding the cause. The Commission has done their work; I embrace their report and believe that I have set into motion the initial steps to return the Space Shuttle to safe and effective flight. Their report is a roadmap for me, and I intend to use it as my mandate for action. Thank you for the opportunity to testify before your Committee today, for NASA needs your support and guidance as our Nation returns to space flight.

Admiral TRULY. Mr. Chairman, if possible, I would like to invite Captain Crippen and Mr. Aldrich to the table to assist if there are questions that committee members have that they could help us answer.

Mr. ROE. OK, why don't we do that right now? That's a good idea, so if Captain Crippen and the others would come up to the table.

Before we go into the question period—again, for the benefit of the members of the committee—the teams, the support task force teams that both Dr. Fletcher and Admiral Truly spoke to during their testimony will be visiting with us this afternoon, and tomorrow, particularly, so that they will have—tomorrow, I believe it is—we'll have the opportunity, in view of the fact that they were a bridge or a catalyst between the agency and the Commission, we'll have the chance to review their work and question their work and any part or piece that we might be specifically interested in. I think that's going to be profitable tomorrow, so I think some of those points that will be made can be best handled at that point.

I have a couple of specific questions that I would like to ask, but I'm going to defer now to our distinguished chairman, the distinguished Representative from Florida, Mr. Don Fuqua.

Mr. FUQUA. Thank you, Mr. Chairman.

Dr. Fletcher, you mentioned in your prepared statement about the relationship between Congress and NASA. I noticed that while fingers are being pointed, it's pointed at Congress, and I think probably we should share the blame.

But I might point out, those who have said that we are too cozy with NASA, I think, need to look at the record. And maybe you are familiar with that from your days prior in NASA. I think when you look at the record, and particularly the gentleman that served in the last number of years as chairman of that subcommittee, at the number of days of hearings that they hold in extreme detail of the NASA budget and the questions that are asked—not only that, but the field trips that are made to the NASA centers and even the contractors, for that matter, to try to get a better grasp and ask questions about what's going on—so I would like to, not in a defensive manner, but to say, check the record before you start saying that. Maybe some of us are guilty of being supporters of the Space Program, and I plead guilty. But that doesn't mean that we have always agreed—and you even mentioned, sometimes with a skeptical view—with some of the decisions that NASA has made, and there hasn't always been unanimity of agreement in all of the things that have taken place. Sometimes NASA hasn't liked the way we've redistributed money, and sometimes we have not agreed with the way that NASA proposed to spend the money. But I think if you also look back, you'll find that never—that I recall—we've ever reduced money for flight training and operations and safety during the course that I have remembered. We have made other changes; maybe you can elaborate from your memory, which is probably hazy like mine is, when you were serving before. I think we have tried to work and support and be proponents of the Space Program. I think it's very important to the Nation.

But I think that those that say that need to go back and check the hearing records and so forth. I think they'll come away with somewhat of a different perspective about that.

Dr. FLETCHER. Mr. Chairman, you are absolutely right. Over the years that I remember and also I've followed NASA in the years since then, in some detail, this is perhaps the most thorough and most critical oversight group of any that NASA deals with in Congress, although Congress as a whole has provided plenty of oversight. On the other hand, having said that, they've been supportive of us when we were doing the right thing and critical of us when we were doing the wrong thing.

Mr. FUQUA. I want to mention to Admiral Truly—I noticed you were talking about the landings, safer landing in your report, landing safety. And in addition to the tires, brakes, and nosewheel systems, I had even—2 days before—as a matter of fact, on January 26, I had a conversation with then-Acting Administrator Graham about the possibility of installation of a doppler radar system in the KSC area that could be used for more instant weather prediction. Is that included in your plans, to pursue that? They're planning to put one in Florida, and it would be an excellent test or demonstration facility, located in that area to give more accurate weather prediction for launch and landing.

Dr. FLETCHER. I might ask Arnie to comment. He may know a little more about where we are there, but I can assure you we are looking at advanced weather forecasting capability down there and we are also looking at some of our own internal NASA work out at the Ames Research Center on advanced systems. We've stood down on that cape runway many times and watched the weather change, and it's been a concern to me and to the crew a number of times. We intend to improve our capability during this downtime.

Arnie, could you elaborate at all?

Mr. ALDRICH. Yes, Mr. Fuqua.

Mr. Fuqua, that system is under investigation, both for application in Florida and on the west coast at Vandenberg, where it would be particularly useful for the kind of conditions there. In addition, we are also proceeding with augmentation of the worldwide capability for weather reporting and analysis at the Johnson Space Center in Houston to advance our capabilities and coverage. So we're looking at all of the ideas we know to make our weather forecasting as up-to-date and as capable as possible for the future.

Mr. FUQUA. Well, I would highly recommend that that be pursued. We are moving into some demonstration projects of the doppler radar system, and I think it cannot only serve as an excellent demonstration area but also serve a very valuable purpose in our space program.

Another point that you mentioned, Admiral Truly, was spare parts. I know every year this committee has added additional money in for spare parts; we've had to twist noses, kick, scream to get NASA to use it, and most times they have not used it for spare parts as it was intended.

I was told by one of the persons—I shall not name—that they had pirated one of the spaceships so much that he could carry in his suitcase what was left of it. I don't think that's good policy when we do that, and I'm glad that the Commission made specific note of that in their recommendations and I'm glad to see that NASA is getting the proper attention. And I might point out, this all happened before you came on board, so I'm not directing this at you; but I just want to, while you and Dr. Fletcher are here, express my concern that spare part money that we have put in—never asked for, the committee put in—was never spent in the proper fashion that we had directed it to be. And that caused a lot of pirating of one vehicle to another vehicle, and I'm glad that the Commission noted that. That is not, in my view, a very good way; I'm glad the Commission realized it, and I'm glad to see you make that point in your statement.

Admiral TRULY. Thank you, Mr. Fuqua. Again, Arnie has been dealing directly with this problem for some time. Frankly, I'm concerned about this and I'm looking forward to having the time and the opportunity to really get with Arnie and look over this whole problem. I'm a little puzzled by it, frankly; my concept of spare parts is not people working on spare parts, but spare parts in the bins to support our airplanes and, in this case, the shuttle. But I can assure you that during our downtime we're going to take a hard look at it and make sure that the flight rates that we build up to after this accident are supportable by the logistics system that we have in place.

Mr. FUQUA. Thank you, Mr. Chairman.

Mr. ROE. You have to leave at 11, do you not?

Admiral TRULY. Mr. Chairman, I believe it's about 10 minutes of 11.

Mr. ROE. Well, we've got a few minutes here. I think I want to—well, we'll take it up later.

Let me suggest the following. I think to set the stage here, both Dr. Fletcher's testimony, which I think was a reaffirmation and a first real, good, strong policy position you have presented so far. I think you have done a splendid job as to where you want to go from there.

Mr. PACKARD. Mr. Chairman, would you yield for just a moment? I think it would be productive if we alternated going to vote and keep the hearing going.

Mr. ROE. That's exactly what we're going to do.

So therefore, where I'm coming from, I think you've set that stage.

The second point is that Admiral Truly has expanded further, which was our natural question, which was, what have you done under Dr. Fletcher's direction? What have you done now to go ahead and implement, not waiting for further, elucidations to come from the Commission because they made a number of very solid recommendations, and you have now brought us up to date as to what you are doing in that direction, as I understand your testimony.

Let me ask you a question. It wasn't clear to me, and I think we ought to get it on the record—I think you developed it more firmly, Admiral Truly, that we were going to follow—NASA will follow the recommendations, all the recommendations, of the Commission? Is that the committee's understanding? Is that the statement that's being made?

Dr. FLETCHER. Mr. Chairman, we will certainly study all of the recommendations, and I see no reason that nearly all of them can't be followed in detail. But, as you recall, some of the recommendations said "consider" certain things. We will certainly consider them in great depth. They did not say to do certain things.

Mr. ROE. I understand that. But I want to get on the record, because that's the beginning point.

Dr. FLETCHER. We will certainly deal with all of the recommendations and have a report for you in a timely fashion.

Mr. ROE. And we'll be asking that.

So, for the following point, is there any recommendations that have been presented that you seriously, from a management point of view, would question at this point in their recommendations? Anything that they have presented that you don't think is the right direction to go? I think that's a fair statement to ask at this point.

Dr. FLETCHER. I think that all of the recommendations are things that are proper recommendations, and we should seriously consider them. I don't know any of them that are not worth considering or, even, maybe the right way to go.

Mr. ROE. OK. I just want to get that on the record. So, as far as you're concerned, the recommendations that have been made will be reviewed in toto and someplace along the line, as the committee calls back for an overview of what you're doing on those recommendations, you'll be able to give us a better idea as to what the substance would be and where we would go from there. Is that right?

Dr. FLETCHER. That is correct, Mr. Chairman.

Mr. ROE. Let me clarify for the record another point. It seems to me that the fundamental, upfront issue is the safety issue which you both spoke to eloquently, and that is first and foremost in your minds in your administrative approach, as it is as far as this committee is concerned. And then Admiral Truly spoke to the issue as far as the critical list, the criticality 1 and the criticality 1-R items were concerned. And again to reiterate for the record, is it my understanding and the understanding from your testimony that you are saying that all of those critical items will be reviewed individually?

Admiral TRULY. That's correct.

Mr. ROE. Totally?

Admiral TRULY. Every single one. And not just those on the solid rocket motor, but on all the elements of the system.

Mr. ROE. And is it the intent to have the process—and I notice that you've abrogated all waivers, so that everything will be looked at, and they will be recertified, each and every critical item on the list; is that a correct understanding?

Admiral TRULY. That is correct. And, as a matter of fact, that process had been set in work by Arnie Aldrich even before I issued the memorandum that was discussed in my testimony. But when I did issue the memorandum that charted a course for us to safely get back to flight, that was a major part of it, and you are exactly right. Every single criticality 1 and 1-R element or specific element of the shuttle system is being relooked at and, if it's found wanting, it will be redesigned and requalified prior to the next flight.

Mr. ROE. And therefore, our first and foremost observation—the first point of management is safety, and that's the direction which you intend to go, which leads me to my final question on safety.

In part of Admiral Truly's testimony, on page 2 at the bottom, safety organization, you mentioned that—

> Although safety responsibility and quality assurance is not my direct responsibility, I am vitally concerned about these activities and pledged to work closely and do what I can to strengthen.

It would seem to me, regardless of what the chain of command is or specific assignment, that safety, No. 1, goes fundamentally to Dr. Fletcher and then second to you, whether it's a direct responsibility or not. So could we clarify that for the record?

Dr. FLETCHER. Mr. Chairman, the reporting responsibility for R&QA, as you know, is to the Administrator of NASA. But we will make that study for all of NASA.

Having said that, however, I don't think it should be said minimally that Admiral Truly is going to take a very hard look at R&QA for the shuttle program. I don't think he meant to imply that he was not going to do that.

Mr. ROE. That's why I wanted to get it clarified. And I think the relationship between yourself and Admiral Truly, being one of your appointees, is critically important that there's no breach in the safety communications point that you were making.

Dr. FLETCHER. Oh, no.

Mr. ROE. That is not what the intent was, and there will be a very close liaison. We understand that.

Let me ask one more question. You spoke of General Phillips being assigned, Dr. Fletcher, to review all aspects of the NASA program management in their internal shuttle overview. That indicates to me—is not—General Phillips was formerly with NASA, and then left? And is he coming—you called him back again? Is that what——

Dr. FLETCHER. General Phillips, Mr. Chairman, has been gone from NASA since the days of the Apollo Program, I believe in 1969 or 1970, and has been with TRW and has just retired as a group vice president. Like a lot of folks that were anxious to help NASA get back on its feet, he agreed to come back almost full-time and pursue this assignment. This assignment, as you properly indicated, is to look at the overall management structure of NASA, which impacts, sometimes directly, sometimes indirectly, on the shuttle management program. Having said that, however, Admiral Truly again will look at the management structure and the communications and the procedures for the space shuttle program as part of his assignment, and I suspect that's one of the things——

Dr. ROE. Well, what I'm leading up to, would it be profitable—and we don't have to make that decision now, or whatever—but I'd like you to consider one point. Sometimes, when we're cleaning our own house, we can't see what's in the corner simply because we're used to seeing it. And it seems to me that we are bringing an eternal—and no effrontery whatever, because General Phillips has an extraordinary, wonderful reputation; I don't mean that at all—but would it be profitable for the agency to also consider looking to the private management groups for re-review from an outside point of view? In other words, if we're just going to review internally what happened to us, even though there's added expertise that General Phillips brings, would it not be a good idea to give some consideration to overviewing this whole operation with some outside consulting private management groups? From the universities, and so forth?

Dr. FLETCHER. Mr. Chairman, when I said General Phillips was heading that effort, he has a series of consultants from all over the country involved with him making that review, all of whom are outside of the NASA organization.

Mr. ROE. Splendid. Could you, Dr. Fletcher—for the record, could you give us a little update response on that, a little bit of a broader view of what General Phillips will be doing? And also, that we have these different experts and expertise throughout the country, from universities and so forth, helping us to make this indepth, solid review? I think it will help a great deal on credibility.

Dr. FLETCHER. We'll supply that for the record, Mr. Chairman.

[Material to be supplied follows:]

Material requested for the record on page 46, line 967 by Acting Chairman Roe during the June 11, 1986, hearing.

General Samuel C. Phillips, USAF, (Ret.), is leading a study of NASA's systems and processes for managing its programs, personnel, and facilities. The study will draw upon expertise in the scientific, technical, and management communities.

Support for the study is being provided by the National Academy of Public Administration. In keeping with its regular practice, the Academy is forming a panel of outside experts in both the study and practice of management to advise and critique the project staff.

We will inform you of the make-up of the panel as it is completed.

Mr. ROE. Those are the questions I want to ask at this point.

Now, who is next? I guess I'm about the only one left. Suppose we take 10 minutes while I go do my duty and vote, and then we'll reconvene. You'll be leaving us, but then you'll return immediately thereafter?

Dr. FLETCHER. That's correct, Mr. Chairman.

Mr. ROE. I know there's a number of questions the members want to ask you.

We will recess for 10 minutes.

[Recess.]

Mr. ROE. The committee will reconvene.

Dr. Fletcher, as you know, has left us for about an hour, and then he will return, and Admiral Truly is leading this team. Therefore, I have concluded my first group of questions and I defer to the distinguished minority leader from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you very much, Mr. Chairman.

Admiral, let me tell you I'm sorry that Dr. Fletcher left, but I'm real pleased with the direction of NASA. As you know, many of us were concerned about what the attitude would be to accept those changes that need to be done, the fact that there were some errors, and let's move on to fix them. At the beginning, it appeared like NASA was rather defensive and, in that mode, it's very difficult to make the changes if you don't recognize that something was wrong. So I'm real pleased to see your statement and the Administrator's statement, moving in a positive direction and saying, let's go. I think, perhaps, we may have some little problem on down the line, and it's necessary that management impart that feeling all the way through NASA, but I think that's moving pretty good.

Let me ask you, particularly in terms of your testimony on improved communications, both the Commission and your statement mention, in the communications context, Marshall—not in any specific way, but everybody kind of alludes to Marshall when communications problems are discussed. Is that the basic problem? Is Marshall the basic problem as NASA sees it in this whole thing of communicating information up and down the line?

I notice that the Commission says—it talks about the tendency at Marshall to management isolation. I'd like to pursue that a little bit with you, Admiral, if I may.

Admiral TRULY. Yes, sir. I would answer that question in two ways, looking backward and forward. We had a terrible accident, and it was a part of the shuttle system that the Marshall Space Flight Center was responsible for. They have been under a terrific amount of criticism in the report and throughout the investigation. The reason that I mentioned the Marshall Space Flight Center in my testimony was because of the way the Commission had written that particular recommendation. But in looking forward, I would answer that question as absolutely not. Communication through the system, through our flight readiness reviews and our L minus 1 reviews and our change control boards has got to be looked at. And it's not a Marshall Space Flight Center problem; it's a problem that starts in my office and goes right down to the crews, once they're in orbit. It's throughout the system. I don't intend, and I know that Captain Crippen, when he looks at the program relationships that are required to be looked at, is not going to look at the

Marshall Space Flight Center any more or any less than the others. We have had problems; we did have a terrific communications problem on this launch, and I think in the launches preceding it, and it's covered in great detail in that report. But as we look forward, we're going to look through our entire system, just as in the hardware we're looking not only at the solid rocket motor but all of the hardware that's aboard.

So, if that helps you, sir.

Mr. LUJAN. Yes. In reading the reports and in reading all of the different things, it just appeared to me like Marshall was in need of some special attention, but that's not the way you look at it; is that right?

Admiral TRULY. No, I think as we look at it in the future, I envision a program management of the shuttle program that flows just the way the paper says it flows, and that is from me at level 1 to Mr. Aldrich at level II, and then to any level III program office, whether it be at Marshall or at Johnson. Whatever the problems have been in the past, that's the way the program is going to work in the future.

Mr. LUJAN. OK. We'll be looking, anyway, at the additional reports of the Commission and follow through where those bugaboos occurred.

One other thing that kind of stood out in this whole process, as far as I'm concerned, is the question of critical items. I don't know if I misunderstood or what, that under criticality 1 you have some 746 or 748 items, which means that any of those could cause the loss of the shuttle, the loss of life, and all of those things, very serious things. It's impossible to assess 746 items without going back and saying, OK, we've got to decide that, out of those 746, what are the probabilities of accident and what is the severity? Am I correct in that, in my analysis of that?

Admiral TRULY. No, I don't think you are. I think that Mr. Aldrich could comment better than I because he's running that review—even though the number is large, it is finite. The space program is used to dealing with extremely complex designs, and I would disagree that we cannot take each of those one by one. We have a great advantage now. Although we have a mountain of work to do, we have a great advantage to looking at those items now because we have had 24 successful flights, and we have a lot of flight data on those critical items. And so, we can look at the histories of each one. It takes a lot of people; it takes a lot of time. It's not going to be quick. There are some that we were concerned about before the accident, and those are the ones we're looking at first because they're the most likely ones that we might have to make a change to. But before we fly again, we will have looked at every last one, and I would disagree that we cannot do that. I'm sure we can.

Mr. ROE. The Chair recognizes the distinguished gentleman from New York, Mr. Scheuer. Mr. Scheuer from New York.

Mr. SCHEUER. Admiral Truly, you were on the second shuttle, which experienced the worst O-ring erosion of any fuel joint in the history of the program, I believe. In fact, it's ironic, it seems to me, that the erosion on the second shuttle occurred on the same right-hand fuel joint, which is the same joint which caused the *Challenger* accident.

Prior to the *Challenger* accident, the tragic accident and the investigation, had you been informed by NASA management about the O-ring erosion on the second shuttle and other shuttles?

Admiral TRULY. No, sir.

Mr. SCHEUER. Well, how do you feel in retrospect, having flown other shuttle missions without having been informed by NASA of this known, demonstrably evident, life-threatening condition on those shuttles? How do you feel, having been sent up in the air on this extraordinarily dangerous mission without having vital information about the safety of the flight, the crew, the mission, that was there in NASA headquarters, was there in Marshall headquarters?

Admiral TRULY. I think that our investigation and this report clearly shows that the failure of communication of that problem, or the proper recognition of it, was a major failure and led to the cause of the accident. And frankly, personally, I am more concerned not that I as an astronaut and did not know, but that the total program through the level III, then to the level II, then to the level 1 didn't work that problem for that flight and others.

When I was in the astronaut office I frankly felt, and I do today, that the astronauts themselves deserve to be involved in those issues that are critical and are being worked. But I'm much more worried that the issue didn't get worked in the program than I was that I personally didn't know about it.

Mr. SCHEUER. Well, I totally agree with you. But don't you think if you and other flight crew members had known of the existence of that problem, you would have made damn well sure that it had been worked on and solved before the next shuttle event, whether you were on that shuttle or not?

Admiral TRULY. Yes.

Mr. SCHEUER. Wouldn't it have had a mighty prophylactic effect? I don't wish to embarrass you at all.

Admiral TRULY. No.

Mr. SCHEUER. But isn't the greatest assurance to the public and to the Congress, and even to NASA officials themselves, full and complete knowledge by the shuttle team on every aspect of the program? Where their own lives and safety are involved, they would insist on proper, prudent steps being taken. They're all risk-takers. You're a risk-taker; of course you are. But you're a prudent risk-taker.

Admiral TRULY. Yes, we should have known. In answer to your question, we should have known before—the way we should have known is that it should have been worked as a major technical problem, on the top of the table, with everybody concerned. And if it had, I'm sure we would have corrected the problem.

Mr. SCHEUER. It would have been corrected, would it not, after the second shuttle when it first appeared? It would have been corrected before the third shuttle? You wouldn't have launched a third shuttle——

Admiral TRULY. Well, that would be speculation on my part. If you go back to that flight and looked at that particular incident, what the decision would have been, I don't know. But I do know that if it had been worked properly earlier, I believe this accident could have been avoided.

Mr. SCHEUER. If you had been a member of the crew on the third shuttle and you knew of the existence of the O-ring failure on the second shuttle, would you have acquiesced that all signals are go, a launch, a green light on the launch until you were sure that they had solved that problem of the O-ring failure?

Admiral TRULY. If I had known then what I know now, I think the proper thing would have been to stop the program and fix the problem.

Mr. SCHEUER. After the second shuttle, when the O-ring failure was evident?

Admiral TRULY. Whenever the joint design proved that it was not working as it was intended.

Mr. SCHEUER. Right. Right.

In other words, this is not just a failure of communication; this is a failure of decisionmaking. Isn't that evident? It's not just that the information didn't filter to the decisionmakers; it did. But they didn't act on it. They permitted the shuttle crew to take what we all see in retrospect as unacceptable risks. Wouldn't you think that's a reasonable conclusion? And that's what we want to avoid.

Admiral TRULY. I think somewhere, in the various levels of program management, there was a failure in decisionmaking and in communications.

Mr. SCHEUER. Between 1980 and 1985 NASA and the Air Force conducted three studies predicting the probability of failure of the shuttle. Two of these three studies predicted that a booster failure was likely before all of the 500 manned missions were completed. The Sierra study indicated an estimated failure rate of 1 in 70, and the Sandia National Laboratory study indicated a failure rate of 1 in 210. There was another one that indicated 1 in 1,000. But then, by some process of rationalization that I don't understand, NASA Headquarters came up with a failure prediction rate of 1 in 100,000, which was 100 times more optimistic than the most optimistic of these three studies that NASA and the Air Force commissioned.

Didn't these three studies—two of which indicated failure before the end of the series of manned shuttle flights—didn't they sort of send up an early warning signal to some of you? Totally apart from this wildly optimistic of 100,000-to-1 estimate of NASA?

Admiral TRULY. I'm sorry, I'm not familiar with any of those studies and just can't comment. Perhaps Mr. Aldrich might be familiar, but I'm not.

Mr. ALDRICH. No, I'm sorry, I'm not familiar with those studies.

Mr. SCHEUER. Would Mr. Fletcher be familiar with the history of these predicted failure rates?

Admiral TRULY. I don't know, sir.

Mr. ROE. Will the gentleman yield for a moment?

Mr. SCHEUER. Sure.

Mr. ROE. I know you've done quite some research on this. These studies were commissioned by NASA?

Mr. SCHEUER. By NASA and the Air Force, three of them; one that came in with one failure out of 70, one came in with one failure out of 210, the third came in with one failure out of 1,000. And on top of these, NASA predicted one failure out of 100,000, which is 100 times more optimistic than the most optimistic of the three.

Mr. ROE. I think the gentleman, if he would yield further, is striking upon an extremely important, nagging point that every member of this committee, without exception, is concerned about. How could there possibly be 14 incidents, as we understand the issues involved, with some kind of a problem relating to those O-rings, and nothing was given urgency to immediately get at that? I think that's where the gentleman is coming from.

Mr. SCHEUER. Yes, and I'd like to know, was the shuttle designed—each of the components designed—to achieve a probability of success in 99,999 cases out of 100,000?

Mr. ROE. Would the gentleman—

Mr. SCHEUER. And I'd also like to ask them at some point in time, what do they consider a reasonable, expected, predicted failure rate? I think the Congress ought to know what the acceptable failure rate is.

Mr. ROE. I understand. If the gentleman would yield—I don't want to lose this train of thought because I think you're on a very important one.

Mr. SCHEUER. Yes.

Mr. ROE. We're going to be breaking sometime around 12:30. We would like to be able to give you the information that Mr. Scheuer speaks to, vis-a-vis these two or three studies that were commissioned by—what do you call it—NASA, and did that go to the chief engineer, what happened, and how come we don't know about that. I don't mean that unfairly or unkindly. In other words, why don't we—here's an example; and again, I know that we're coming back, being called back, new people involved, but we don't know that those were commissioned. What did they say and what did they do?

So I would suggest to the gentleman from New York, if he will, that we——

Mr. FUQUA. If the gentleman will yield?

Mr. ROE. Yes, of course.

Mr. FUQUA. Those were studies that were commissioned by the Department of Energy in relation to a power system called the RTG that would be used in some upper stages. I don't remember exactly when they came back, but they were also commissioned for the President's evaluation of approval of those launches. They were not commissioned by NASA; they were not commissioned by the Air Force, to my understanding. They were commissioned by the Department of Energy.

Mr. ROE. Where the Chair—I respect the gentleman's enormous background and knowledge—where the Chair is coming from, we are going to get, as we unfold our efforts and energies over the next 3 or 4 weeks, we're going to get people making statements and different presentations that are made that we have to deal with up front for the legitimacy of that particular question. I think that's where the chairman is coming from.

What I'm simply suggesting, in the line of questioning that Mr. Scheuer is pursuing, is that we ought to look into those facts, check with your chief engineer, so we can elucidate as the chairman said.

What we are trying to do here is establish the facts as they are—not hypothetical, what may have happened. What are the facts?

That's what we've got to get at, and this is one of those issues that we have to deal with. Is that a fair commentary?

Mr. SCHEUER. Sure.

Mr. ROE. And we'll take this matter up first.

Mr. SCHEUER. I thank the chairman.

Mr. ROE. The Chair now recognizes the distinguished gentlelady from Rhode Island, Ms. Schneider.

Ms. SCHNEIDER. Thank you, Mr. Chairman.

Admiral Truly, I'd like to focus on some of NASA's supervision of quality control and safety concerns that have come into question, and specifically I'd like to focus on the elements of personnel and also of procedures.

In one of the reports I was looking at here it says that the number of quality assurance personnel dropped from 1,689 people in 1970 to 505 people in 1985, which is a 71-percent decrease in the number of people who are responsible for quality control. And last October, an Air Force study had indicated that they found a shortage of engineers and technicians, so much so that it led to an average of 2,200 work requirements by ground processing personnel that had not been dealt with. And of all of those requirements, only 26 percent of them were scheduled for work.

Now, my question to you is, are we reaching a conclusion that perhaps part of the reason for the accident was a deficiency in not only workmanship but also oversight due to the fact that there were not enough personnel involved to do the kinds of checking and double-checking that should have been done?

Admiral TRULY. If I might respond first with a comment, and then get to your question.

The numbers that you referred to, I believe, have been corrected by the chief engineer, Dr. Silveira, which I can provide for you for the record.

[Material to be supplied follows:]

Material requested for the record on pages 59 and 60, lines 1301 through 1306 by Acting Chairman Roe on June 11, 1986.

It is important to discuss the reduction in R&QA personnel in the proper perspective. Please note that the highly publicized "reduction" concerns only R&QA personnel. The "70% reduction" over the past 15 years included many functions such as metrology/calibration, parts, assemblies and systems testing, material testing, chemical analysis, etc. which were in the 1970 R&QA organizations but transferred to other organizations within the NASA centers. Also, included in the "70% reduction" were in-house flight programs such as Viking, Saturn launch vehicles, and Skylab Apollo Telescope Mount which require NASA inspection/verification on manufacturing, assembly and test operation. The termination of these in-house flight programs, along with the transfer of certain functions, accounts for much of the "70% reduction."

Using the same functional baseline, the number of R&QA personnel in 1970 was approximately 1,030 out of a total population of 32,500. In 1985 we had approximately 580 R&QA personnel out of 22,300 employees. Over the 15 years, NASA had a decrease of approximately 10,200 employees of which 450 were in R&QA.

However, this total reduction of 450 R&QA people includes the reduction in program content for the Agency which is represented by the overall population decrease from 32,500 to 22,300 as well as an effective real decrease in R&QA coverage on the remaining programs. This effective real decrease in coverage can be determined by comparing the percentage of NASA R&QA of the total population in 1970 versus 1985. In 1970 we had 3.2% of the employees in R&QA, while in 1985 we had 2.6%. The decrease in R&QA was 0.6% or approximately 135 people. This means that of the 450 drop, 135 represents a decrease in coverage while the remainder of the 450 (315) represents a decrease because of total program content reduction.

Even though we had a reduction in R&QA personnel, our detail review of the quality operation did not reveal that we missed any of the quality control check points which may have contributed to the accident. We firmly believe that the checks and double checks by NASA personnel, our Government QA Specialists, and our contractor QA personnel were adequate. We are reassessing the entire quality operation for the purpose of identifying ways we can strengthen the system. This reassessment will include a study of the staffing in SR&QA.

Admiral TRULY. However, that is not to say that the safety, reliability, and quality assurance program in NASA was not a major focus of the Commission's recommendations. And as I said in my statement, I can assure you that I will personally join that effort to take a look throughout the agency, and particularly in my responsibility throughout the Space Shuttle Program, to make sure we have the right kind of people on the job.

To answer specifically your question, I think that that was something that the Commission discovered in its investigation and was not a direct cause of this accident. But it is something that was uncovered, and I'm sorry there was some confusion on the numbers that became public, and we should straighten those facts out for you. But I don't think it was a direct cause of the accident. It was something that the Commission ran into. It's something we should fix, and we will do that.

Ms. SCHNEIDER. So what you're suggesting is that there are an adequate number of personnel available for monitoring and quality control supervision?

Admiral TRULY. I can't say that. I have not had the opportunity personally to go through the detail. What the chief engineer is going to have to do is go through all of our contractors, look at what industry standards are for systems that are complex like this, make sure that we have not only the right numbers but the right kind of trained people, that we have the right sort of supervision, and we look at it from the top of NASA. That's what the Commission recommended, and I'm sure that is precisely what we're going to do.

Mr. ROE. Will the gentlelady yield?

Ms. SCHNEIDER. I'd be happy to yield, Mr. Chairman.

Mr. ROE. I think for clarity for the record, the gentlelady is striking on a very important point. And if I can relate her question back to the earlier comments that Admiral Truly made in his presentation, we did pursue that. We came back and said that one of the key critical issues that NASA had to do was to investigate and inspect all of the critical items that were involved, of the 700-some-odd items that were involved.

The logical question that the lady is asking, I believe, or that our colleague is asking, is, what is it going to take to do that? And you yourself made the point of view that there is an extensive number of people that would be involved.

And then, on a legitimate, followup question, if the lady would yield further—our gentlelady and colleague would yield further—is, is NASA going to use their people, quality assurance people, to review and inspect these critical parts? Or are they going to use outsiders? Or a combination of both? How do we get the assurance that you have enough personnel? What process will you be following, as I understand the basic question? Is that a fair analysis of the question?

Ms. SCHNEIDER. Yes. That's it.

Mr. ROE. That's the question I think she's asking.

Admiral TRULY. I agree that is the question, and that is precisely the study that needs to be looked at to determine where we are in the quality assurance area.

Within the Office of Space Flight, I have looked at just the numbers. I have not had an opportunity yet to put my name behind the report because I've just seen it. But I know that for two of our major contractors, the numbers of quality assurance personnel on the job appear to be quite adequate, at Rocketdyne with the main engines and also the numbers that I've seen at the Rockwell plant. The numbers have changed over the years because we have been out of production. You need more quality people when you're producing hardware.

Mr. ROE. If the gentlelady would yield further?

Ms. SCHNEIDER. Yes.

Mr. ROE. I think it would be profitable by tomorrow if you could respond to this question as to some thought process that you may have developed that your people will think about in the following direction.

The question before us is the deepest of concern and the paramount issue of safety; I think we all agree to that. The second point that the gentlelady is asking is that, in order to ensure that issue in the first step as far as technological hardware is concerned, you and your colleagues have testified that they are up front, and priority No. 1 is to get your inspection and reassurance. You've cancelled the waiver positions on the critical items, and those are all going to be gone through again because the question was asked by other members that some of those critical items—all of those critical items—in effect, if they were defective, could create a problem and a serious one. That's the question.

Now, the second question we're asking, there was some question as to whether or not the contractors alone should be the ones who do the quality assurance as working for NASA, or does NASA consider the issue to be important enough and serious enough to have their own cadre of expertise to double-check on the contractors? Particularly, looking at part of the testimony that was given yesterday where they came back and said, one of the contractors did not perform their contract within the ambient levels that they had to perform it in.

So what we simply want to nail down, if I'm correct for the gentlelady—

Ms. SCHNEIDER. You are.

Mr. ROE [continuing]. Is nail down the point of view as to what process is NASA going to invoke to be able to review the critical list to improve the quality assurance issue. Will you rely more upon NASA personnel working directly for you, the Government? Or are we going to put off more and more of that to the private contractors who are working for us? How do we get that balance, and what do we do to test?

Is that a fair appraisal of what the gentlelady said?

Ms. SCHNEIDER. That's it.

I appreciate my interpreter doing such a fine job. [Laughter.]

Mr. ROE. The gentlelady from Rhode Island.

Ms. SCHNEIDER. Well, I would like to continue on part C of my questioning; and due to my magnanimous nature in enabling the chairman to clarify this, there are some other points that I would like to have clarified. And if you don't have this information, I would appreciate that we obtain this for the record, perhaps at a later time.

But it seems to me that, at the same time that we were watching the levels of personnel decline since 1970, I'd like to know what the percentage was in increase/decrease or maintenance of status quo insofar as public information and public relations was for NASA over that same period. Do you happen to have the answer to that on hand?

Admiral TRULY. No; but I'll be pleased to provide it.

[Material to be supplied follows:]

Material requested for the record on page 66, line 1439, by Ms. Schneider during the June 11, 1986, hearing.

As of the end of FY 1970 NASA had 131 employees in public information and public relations functions. The following table shows the comparable end fiscal year totals and the number and percentage change from FY 1970 in two year increments through May 31, 1986.

	Number of Employees	Difference From FY 1970	Percentage Change From FY 1970
FY 1970	131		
FY 1972	98	-33	-25%
FY 1974	97	-34	-26%
FY 1976	98	-33	-25%
FY 1978	92	-39	-30%
FY 1980	87	-44	-34%
FY 1982	101	-30	-23%
FY 1984	116	-15	-12%
May 31, 1986	112	-19	-15%

Admiral TRULY. As a matter of fact, I can provide the corrected numbers that were testified to by Dr. Silveira, for the quality assurance people.

Ms. SCHNEIDER. In addition to the quality assurance personnel, I am interested in looking at the budget that has been utilized over that same period of time because it appears to me, Mr. Chairman, that we have been seeing over that time period a very aggressive public relations campaign in support of the shuttle program. And I certainly understand the favorable publicity and the campaign that was helping to create an atmosphere which would lead to support of this program, but I am concerned about that.

I'm just going to ask part D of my questioning, here, which relates also to procedures of those personnel.

The General Accounting Office had indicated that NASA had cut or delayed one-half billion dollars in spending on safety testing, design, and development from the time the shuttle began until the *Challenger* disaster. Now, the reasons, I understand, that those procedures were eliminated was because they were proven—or it was indicated—that they were not cost-effective. I would appreciate it if you could elaborate on the decisionmaking discussion that indicated that it was no longer cost-effective, unlike the Apollo space program where various procedures were tested and they design it, and then they build the prototype, and that prototype was then tested.

The idea of eliminating this procedure because it was not cost-effective, I'd like some more justification for that, please.

Admiral TRULY. Again, I'm going to have to respond for the record on that. Those happened in years that I'm not personally aware of. I will be pleased to try to get you the information for the record.

[Material to be supplied follows:]

Material requested for the Record on page 68, line 1478, by Ms. Schneider, from the hearings held on June 11, 1986

We reviewed the NASA historical records and found that there was a series of review meetings held in the mid-1970's to realign the Shuttle development testing programs due to the prevailing budget constraints. During these reviews and the subsequent development program, some testing was deleted, which ultimately resulted in significant cost savings.

The prior Apollo program concepts of dual development efforts to obtain a single end item (component or system) were not implemented.

Some component testing was deleted by relying on the development testing of larger assemblies which included those components.

Some testing of noncritical items was deferred to the development flight tests.

The total-orbiter acoustic/vibration tests and some subsystem thermal vacuum tests were deleted by (1) relying on our knowledge of materials and designs performance in space as gained from preceeding NASA program experience and, (2) depending on vehicle flight tests. Full confirmation was achieved by flying the Shuttle, while heavily instrumented, through a series of progressively more difficult flight tests to actually measure the operational acoustic/vibration, thermal and other environmental effects, and performance.

It is clear, however, that NASA did not delete any safety items or systems, or the planned or expected testing of the safety systems or related safety concepts or practices. Safety related systems were thoroughly tested even where they were redundant.

Ms. SCHNEIDER. Thank you, Mr. Chairman. I, for the record, would just like to say that in looking at various pieces of information, there seems to be a trend between the number of dollars spent, the personnel, and the procedures, and I'm curious to know what kind of conclusions we might be able to draw by looking at all three of those aspects. If I had more time, I'd ask how that could be looked at in an even larger picture insofar as NASA's budget versus the Defense budget for space purposes.

Mr. ROE. You will have time for that because we're going to go around again.

Ms. SCHNEIDER. Thank you.

Mr. ROE. We'll start with our next colleague, Mr. Boehlert, the distinguished Member from New York, and we'll go until the second bell rings and then you'll have your time when we come back. You can start now, yes.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Part E of my colleague's question, and I think she addresses a very important and critical point.

The information provided us by staff indicates, for example, that in June of 1970, Marshall had 615 people assigned to reliability and quality assurance; and in August of 1985, that number was down to 88, which is an 86 percent decrease. So I think it's important, Admiral Truly, that we do have those figures because I think we all agree that safety is first and foremost.

If I may, I'd like to address something that I addressed yesterday with Secretary Rogers. And the reason I want to do so is because a great many people have asked me—and I'm sure they have asked our colleagues—about the crew of the *Challenger*. A great many Americans think that if Congress had provided more dollars, or NASA had established different priorities, it might perhaps have been possible to save the crew.

Is there any bail-out system or ejection system now operational, or even in the conceptual stage, that if part of the *Challenger*—would have permitted the saving of the crew?

Admiral TRULY. I believe in this accident, there is no system that is in development that could have saved the crew——

Mr. BOEHLERT. Because of the time factor, 73 seconds, the thrust and——

Admiral TRULY. The issue of egress and escape has been studied and argued in the shuttle program since its inception. The decision was made that the way to provide the best safety was to put that money, those dollars, into the reliability of the system during the first stage. The only sort of system that I, frankly, am aware of that could possible be of use during the first stage would involve a combination of thrust termination on the solid rocket motors and, essentially, a detachable pod as part of the cockpit of the shuttle. That was determined just not to be a feasible trade in the early days of the shuttle program.

As we look at the issue now—and as I said in my testimony—we are reopening all of those possibilities, which vary from a major change to the system which could be accommodated all the way down to the possibility, at least, of a bailout capability in controlled gliding flight. We're just going to have to get those studies in and make the risk and gain trade-offs to decide what to do. In every study when we made those tradeoffs before, particularly after we had gotten started in the program, the gains in the system to make a change did not balance out against the risks involved in modifying the hatch or putting in ejection seats or so forth.

Mr. BOEHLERT. But in this instance, the answer is clearly no to that question?

Admiral TRULY. That's correct.

Mr. BOEHLERT. OK.

Mr. ROE. Would the gentleman yield on that point?

Mr. BOEHLERT. I would be glad to yield, Mr. Chairman.

Mr. ROE. By the same token, I think you are developing a more positive approach. And the idea of balancing the system—and forgive me for being, not emotional, but what kind of a figure do we assign to a life? I mean, if we were dealing in equipment and material and things that we make with our hands as part of the system, and we evaluated that, what kind of cost evaluation did we make when we had seven lives involved? And I don't mean to come down on you.

Now, I just wonder what weight we put to a life in this engineering system we're figuring versus the point of view of whether we can or cannot afford it. And I don't mean to mislead anybody and second-guess your initial point when you talk about this particular flight, but it seems to me in a systems evaluation—and I don't want to belabor the point—that we ought to be talking about—and I think you're moving in that direction—we're going to take a very serious look at this and a very indepth look at what we may be able to do to be able to help astronauts in different modes, acts and potential modes. Is that a fair statement?

Admiral TRULY. We are looking at that specific question. The review studies of what the possibilities are with the shuttle system today are not in. When they are evaluated, first by Mr. Aldrich at level II, a recommendation will be made and we'll deal with it.

Mr. ROE. If the gentleman will yield further, and you'll have your time when we return, but we will be looking in our next oversight—because our oversight will be based continually on safety—we're going to be looking to that particular issue as to how we put the systems cost-analysis benefit ratio to the loss of a human life. And I think you would agree with that.

Mr. BOEHLERT. Mr. Chairman, if I could follow up on that, and you had promised me some additional time after this——

Mr. ROE. Yes, we'll give you more time.

Mr. BOEHLERT [continuing]. I'm just wondering on what level of safety we're looking for before we decide to put people in space. For example, just the other day Dr. Fletcher is quoted as saying that NASA remains committed to the civilian in space concept. But he also has said that will be delayed until shuttle flights are deemed safe enough for them, for the civilians. Are we going to have two levels, one level of safety for the astronauts, another level of safety for the civilians? And that's—I'll ask Dr. Fletcher to expand upon his response to that when he does get here, but I'm wondering where the dividing line is going to be.

Admiral TRULY. To me, a life is a life.

Mr. BOEHLERT. It is to all of us.

Admiral TRULY. The question is, in the shuttle system, are there things that we could do that would improve the crew escape posture that makes the risk less than it is today? I want to make sure that you realize that in many cases, things that are approved enter new risks into the system; for instance, pyrotechnics that would blow a hatch away, that would save you in a certain situation and kill you in another.

So it is a subjective question, and the question of citizens in space is a policy question. But the same protection will be provided at whatever level to whoever the occupants of the shuttle are.

Mr. SCHEUER. Mr. Chairman, I think it is relevant to note at this point, in amazement or disbelief, I might say, that while the NASA authorities have been using a figure of one predicted accident out of 100,000 flights, we had the testimony just yesterday of George McKay, a project engineer at the Marshall Space Center, who said yesterday that 20 years ago, Marshall safety engineers predicted a flight failure in every 20 to 25 manned flights. And he said, "We didn't tell anybody about it at that time because it would have scared the hell out of everybody."

Getting to your question, Mr. Chairman, of the value of a single life, when we have an ongoing program where the top safety officials know in their heads that there's likely to be a failure every 20 or 25 flights, when we have a series of 500 manned flights planned, they don't rate human lives very highly if they proceed on that intellectual risk assumption.

Mr. ROE. Well, if both gentlemen would yield, because we have to vote, we will suspend. But where I'm coming from on this question, which I realize is a sensitive, emotional question as both our colleagues do, is part of the policy decision that will follow as we unfold our observations over the next 2 days in discussing with you the details and facts. They're going to based as to what ratio the manned space flight should play to unmanned space flight; that's where we're coming from in those questions.

So we'll suspend for the moment and return in 10 minutes.

[Recess.]

Mr. ROE. The committee will reconvene.

If I can have the attention of the Members and our guest witnesses, what we plan on doing is recessing from 12:30 to 1:30. And when we return, we think it would be profitable to demonstrate for the Members the motion picture that's there, and then we'll continue on. That will give them a good insight, I think, into what happened, those who haven't had a chance to see that before.

When we broke up it was Mr. Boehlert's time, and we defer to Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Hindsight is always 20/20, and I think all of us agree as we look back that had the conversation between the officials of Morton Thiokol and NASA at Marshall been reviewed at the very top, there probably would have been a decision not to launch.

Now, I note in Secretary Rogers' report that he is recommending—and it's a recommendation that I fully support—that in the future, prelaunch conferences be recorded so that we have a permanent record. But we don't want just a permanent record to review sometime in the future, God forbid, should another tragedy occur. What we would like is a permanent record so at the very top, these conversations can be reviewed. Had that occurred in this instance, the decision not to launch probably would have been made.

So, Admiral Truly, could you address that point? No. 1, do you support the recommendation that these pre-launch conferences be recorded? And No. 2, can we go a step further and receive some assurances that, at least at your level and hopefully Dr. Fletcher's level, that will be reviewed so that you will have the benefit of discussions like the one that occurred with respect to the O-ring?

Admiral TRULY. This is specifically the kind of recommendation in the report that I'm going to ask Captain Crippen to lead a group and take a look at; that is improved communications and the very structure of the process in the decision to launch.

I might ask if Mr. Aldrich would have a comment to your question since he has participated directly in the flight readiness process far more than I have personally.

Mr. BOEHLERT. Fine. Mr. Aldrich?

Mr. ALDRICH. Yes. Well, I would comment that we have been looking precisely at those kinds of augmentation to the formality of the flight readiness process. Prior to the Commission's report, in anticipation of that finding on their behalf, both the recording of the meetings and the more formal requirement for participation from all organizations and formal structure of the timing of those meetings. What I have done is instituted some specific proposals.

Mr. ROE. Can the gentleman pull that microphone closer, please?

Mr. ALDRICH. I'm sorry.

I've instituted some action to provide a series of specific proposals on the readiness review process to provide to Admiral Truly and now to Bob Crippen as a basis for starting some of the re-look and final decisions in those areas following the Commission's report based on the experiences we have been through and our understanding of them.

Mr. BOEHLERT. And one final question, if I may, Mr. Chairman.

Dr. Graham, in your new role as science advisor to the President, could you expand a little bit on the role you envision for yourself in that office in connection with direct liaison with NASA? And I'm assuming the Senate will be generous in their confirmation.

Dr. GRAHAM. Yes. As you know, I'm subject to confirmation and wouldn't want to intrude on the prerogatives of the Senate to speak to that position until I'm confirmed. However——

Mr. BOEHLERT. Incidentally, when you're talking about the Senate, you're now in the bleachers. That's the grandstand over there. We're after the facts, and they're doing a lot of—if yesterday is any indication of what's going to happen during this proceedings—a lot of showmanship over there. I think you're seeing, in this committee, a determined effort to get at facts and have a good exchange.

Dr. GRAHAM. I will certainly continue, if I am confirmed to that position to take a deep and consistent interest in the national space program and in NASA's activities, both the program of returning to flight and the other activities that NASA will be involved in, as a major contributor to the national space program and as the leadership within the Administration in the civil space program.

Mr. BOEHLERT. Well, as a practical matter, when you were Acting Administrator of NASA did you have steady and frequent contact with the Office of Science Advisor? I recognize it's been vacant for several months now.

Dr. GRAHAM. Yes. First through Dr. Keyworth and his staff, and then through Dr. Mateg, and now Dr. Johnson. There is a steady flow of traffic and discussion between NASA and that office, and I believe it's very constructive and should be continued.

Mr. BOEHLERT. OK. Thank you very much.

Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Missouri, Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I'd first like to ask, this committee has been told by NASA in recent briefings that induced environment criteria for the SRB were signed off before the STS-1 in verification compliance notice 12A11. I'd like to know if NASA can provide us with the documentation supporting this decision.

Admiral TRULY. Yes, sir, we will.

[Material to be supplied follows:]

Material requested for the record on page 79, line 1747, by Mr. Volkmer during the June 11, 1986, hearing.

There was no SRB induced environment verification waiver pre STS-1. Enclosed find a copy of VCN 12A11 which shows that to be the case. (Note that the copy is a composite of multiple, identical forms which were processed in parallel by different functional areas. The individual copies are on file at JSC. The composite was prepared for Shuttle program level sign off prior to STS-1.) On the second page of the VCN, there are three incomplete requirements. None were SRB related and as the resolution section indicates, all were scheduled to be complete prior to STS-1. A check with the System Integration Office on July 16, 1986, confirmed that no waivers to the JSC 07700 Volume X induced environment verification requirements were in effect at the time of the STS-1 launch.

Enclosed supporting data also includes some documentation which will clarify the VCN. This data also includes page 3-40 of JSC 07700, Volume X which establishes the general requirements for each Shuttle element to be compatible with defined induced environments. The six pages (10.11 to 10.11-12) are from Appendix 10 of the same volume. These pages provide definition of those induced environments and provide applicable references.

Mr. VOLKMER. All right. Thank you. I'd like to have it within a week, if at all possible.

There is also, in reviewing the Commission's report, a great deal of confusion involving the, say, environmental criteria, temperature, wind, everything else, rain, that the solid rocket motor was expected to meet. And can you tell us what these criteria are, especially the ambient temperatures expected and the safety factor and the design? Or can you provide us documentation from the contract between NASA and Morton Thiokol stating the exact temperature criteria that the motor would be required to meet?

Admiral TRULY. If I might, if I would pass that question to Mr. Aldrich, who is the level II program manager.

Mr. ALDRICH. Mr. Volkmer, my understanding in reviewing this from the level II organization is that early in the program, an environmental criteria for launch performance for all elements of the shuttle system was established at a range of 26 degrees Fahrenheit to 99 degrees Fahrenheit. This was initially put on contract, or it was applied through my level II organization formally to all projects in the shuttle system for them. In turn, to apply directly to the contracts of their contractors who provide the hardware for the system.

In the evolution of the program the lower limit, the 26 degrees Fahrenheit was subsequently raised to 31 degrees Fahrenheit but was carried forward as the requirement from that time forward and has not only been on requirements for each project to design to, but also been in the launch commit criteria document that we have used for every flight as criteria for flight performance.

My understanding of the formal documentation is that that was applied to each project, including the Marshall projects, and that formal certification was provided back from all projects in the program, that elements had been designed and certified to perform within those ranges.

Now, within the solid rocket booster it does not break the booster further, as an overall requirement, down into subelements or subcomponents; it merely specifies that it can perform within its design spec, within those temperature ranges for those temperatures at launch from either east or west coast launch sites.

Mr. VOLKMER. And the SRB was supposed to be certified down to a temperature—overall temperature of the SRB—of 31 degrees?

Mr. ALDRICH. For launch, yes, sir.

Mr. VOLKMER. For launch.

Mr. ROE. Would the gentleman yield for a moment on that point?

Mr. VOLKMER. Well, could I ask my next question first? Then I will yield. And that is that I would like to be provided the documentation for that certification for the SRB, including all the testing that was done by the contractor to arrive at that certification.

Mr. ALDRICH. Mr. Volkmer, the documentation that I would have direct familiarity with would be response from the Marshall project to the level II program that says that those requirements have been fully met. The details of the contract and the certification testing between the Marshall Space Flight Center and the Thiokol Corp. would be a direct question, I think, appropriate to Mr. Jack Lee of the task force that has investigated in detail that aspect of the certification. He will have more direct knowledge of that than

I, although I am sure we can provide what documentation the task force has put together on that subject.

Mr. NELSON. I have that documentation right here.

Mr. VOLKMER. All right; fine.

Mr. ROE. I think it would be profitable if I understand where the gentleman is coming from. Were actual physical tests made, or were these determinations made by computer model analyses? In other words, where did these temperatures come from?

Mr. ALDRICH. In terms of the requirement?

Mr. ROE. Yes.

Mr. ALDRICH. An analysis of the expected range of performance that the shuttle system would be required to perform at was determined. Some of it was determined by analysis, and a wide range of environmental conditions are determined in order to provide the design specifications for the shuttle systems each to meet. The temperature criteria for launch was, as I understand, a fairly direct assessment of the likely conditions that we would expect to see during the norm of the program in terms of design requirements and launch conditions.

Mr. ROE. Well, the gentleman—I have other questions to ask on this issue, but it's your time. I defer back to you.

Mr. VOLKMER. I'd just like to ask—I know my time is about to run out, but I would like to ask either Mr. Aldrich or Admiral Truly, in your review of the critical items list—as I understand it, you are reviewing all parts, the 1, 1-R's, the 2's, the 3's, all of them—is there going to be, or will you have the National Research Council, an audit panel, be implemented during this review or utilized in any extent? As I understand it, the Commission made that recommendation.

Admiral TRULY. I was not aware they were going to make that specific recommendation, but I frankly welcome it. We will have to, obviously, talk to the National Research Council and work out an appropriate context in which they can perform the audit to this review that we're conducting.

I think that at some point it might be very helpful on this criticality 1 and 1-R review that we invite Mr. Aldrich to give you a good description of it because it's come up several times in the questions, and I think that in the hearings it might be very helpful to get a better and more detailed description of what that review is.

Mr. VOLKMER. Mr. Chairman, if I may comment, I would like to have a little more detail of how that review is taking place and who is doing the actual review, especially as a result of reviewing the Commission's report in regard to the SRB and the fact that the joint was put on the 1-R list and then put on the 1 list, and then we end up having nothing but waivers. So I have some questions in regard to that. From the outside, I think that—it's not that I don't trust everybody, but maybe it would be better to have someone on the outside actually doing this audit, as well.

My last question has to do—what was the actual temperature at time of launch, the ambient temperature?

Mr. ALDRICH. Well, again, I think it would be better, perhaps, to ask someone from the task force, perhaps Bob Crippen. My knowledge of that is that there were several readings for the temperature at launch, depending on how high above the ground on the service structure, and my understanding is it was in the range of 36 degrees Fahrenheit to 38 degrees Fahrenheit.

Mr. ROE. If the gentleman would yield, that's a legitimate question and you're suggesting, Mr. Aldrich, that we would ask them.

Those team leaders are going to be here tomorrow, Hal, and please propound the question again at that point to get it on the record. And I agree with you, because I want to add to that line of questioning. I will give you a copy of these three or four questions that we want to get into the record, to respond this afternoon. I want you to think about them a little bit. For example, we're saying that in general, all Government procurements require a qualification of test, or an equal test, as a condition of acceptance, and assures that it is designed to meet and will operate in the expected environment. That's the fundamental question. Then we're going to ask you, was there a qualification test call on the design specs for the joint? What were the quality test specs for the joint? Did the joint and seals pass the quality test? And four, was the 51-L flight environment within the equal test envelope?

We'll give you that to take a look at so that we can ask those questions of you this afternoon, and that will be more helpful, I think, in responding along the line of what Mr. Volkmer is speaking to.

Any further questions, Hal?

Mr. VOLKMER. No, that's all. Thank you, Mr. Chairman.

Mr. ROE. All right.

The next person—the next member is Mr. Fawell from Illinois.

Mr. FAWELL. Thank you, Mr. Chairman.

Yesterday I propounded a question to Neil Armstrong, and it had to do with his statement that there had been a change of attitude or mindset or policy, or I guess call it what you may, at NASA in regard to, just in general, the "can do" attitude as he described it which prevailed at one time, and the idea that a launch would be presumed to be unsafe and would have to be rebutted, to an attitude now that would be best described as saying that a launch is safe and you're going to have to rebut the safety features of that. And I asked him the question as to when that mindset or when the policy appeared to change, and he couldn't pinpoint it, nor necessarily get too specific, but I did make reference to an act which, at that time, I didn't know the correct name, but it's the National Aeronautics Space Council, or what is called the White House Space Council which at one time was in effect; and I believe in 1973 President Nixon unilaterally, by Executive order, disbanded that.

I've had several who have mentioned to me they felt that NASA thereafter was described by one as a headless agency and didn't have that guidance from on top which certainly sets broad, subjective policies such as safety and other subjective policies.

Could I have some response, Admiral Truly, from you in that regard? Do you think the abrogation of the White House Space Council did have a detrimental effect on the basic attitude and positive, can do attitude and presumptions to which I've made reference?

Admiral TRULY. I'm afraid that I'm like Mr. Armstrong, Neil, who I'm sure responded to that question yesterday. I frankly don't think that the absence or presence of that body watching over the space program was a specific act that changed an attitude within the agency. As a matter of fact, I think in general, the attitude within the agency hasn't changed. I know as short as 2½ years ago, when I was at full-time duty in the shuttle program in the Astronaut Office, a large percentage of our time was spent in the office—and also in the control boards, and so forth—in safety, and I think that continued right up to January 28.

The chain of events that led to this accident, though, undoubtedly did include subtle pressures that caused the workload to go up and to steal from the attention that people were able to pay. However, I don't think that those were the cause of this accident. I think this accident was caused by a specific failure within the system to see a problem that was quite apparent, and was waving a flag and should have been caught. And I think the body of this Commission report concludes the same thing. It is my duty and goal to make sure that before we fly again, that whatever led to this tragic event will not happen because of any problem of attitude within the agency.

Mr. FAWELL. Would you agree——

Dr. GRAHAM. May I add one comment to that, please?

Mr. FAWELL. Certainly.

Dr. GRAHAM. Of course, as you know, Mr. Fawell, this administration has had a very strong interest in the space program over the last several years and has, in fact, conducted frequent White House-level reviews of space policy. But the thing to remember here is that the involvement of the Executive Office of the President in the space program has been at the policy level; and President Reagan has, in fact, provided strong policy guidance for the program. The implementation of that policy rests with the agencies, which is NASA. Today, the generation of the policy is done through an interagency process which is led by representatives from the National Security Council at the working level, and finally by the President at the top level. And that process has generated strong policy for the space program over the last 5 years.

Mr. FAWELL. Now, you are talking about the Senior Interagency Group on Science?

Dr. GRAHAM. In fact, the hierarchical structure starts with the Interagency Group, which involves a number of agencies of the Government. And today, more agencies than ever before are involved in the space policy because space has become such an integral part of the activities of so many agencies, from Justice Department, Commerce, Transportation, NASA, and on.

After that is the Senior Interagency Group; after that is either the Cabinet or the National Security Council, and finally, the President himself.

Mr. FAWELL. Now, I have only hearsay to report; I am by no means an expert. I have had people tell me that there is bureaucratic entanglement insofar as this particular Senior Interagency Group and that, as a result, NASA has been left in a rather independent status so that it can make many of its decisions without real strong policy coming down. I don't know how accurate that is, and I realize that that has not been in being for any length of time.

My feeling, though, is that basic policy on emphasis of safety comes from on top, and I've had a number of people express to me that the White House Space Council, which was abandoned roughly in about 1973, was doing a very fine job in giving that on top guidance, and that its guidance—especially in terms of emphasis on safety and the presumption being that it's unsafe and it must be rebutted, being, as Neil Armstrong has indicated, somehow that concept was lost and reversed, that the White House Council had a great deal in putting that kind of emphasis from on top onto NASA. That's the reason I have propounded those questions, and I am seeking only to see if we indeed need that kind of—and I think there is legislation pending that will reinstate the White House Council, as I understand it. It would appear to me that that may be something that did contribute to what Neil Armstrong, I think rather aptly, referred to yesterday.

Thank you, Mr. Chairman. My time has expired.

Dr. GRAHAM. May I just respond, Mr. Chairman, briefly?

Mr. ROE. Dr. Graham, of course.

Dr. GRAHAM. The interagency process dealing with space issues today is considerably more complex than the process was in the early 1970's. I view that as a tribute to the space program, to this committee, and other Members of the Congress who have, in fact, helped to make the space program an integral part of so many of the activities of the Government, and so many of our international activities, as well. That necessarily leads to a more complex process because many more interests are involved now than they were a decade or a decade and a half ago.

Nevertheless, there has been a continued strong leadership through this administration in the space program and in the policy of the space program which has been generated in the White House. NASA's task in the civilian area is to implement that policy; and if we have encountered a difficulty in the safety area in the last two decades, as we clearly have with respect to the *Challenger*, I don't believe it has been lack of sound policy concerning safety; it has been too much the assumption that safety is inherently wired into the system, and can't leak out, no matter what we do. That's not a correct assumption. We have to work every day to keep safety in the system, and one of the consequences of the *Challenger* accident—as, in fact, was the consequence of the Apollo fire nearly two decades ago—will be to rededicate the agency to making its implementation of space policy based on an active pursuit of safety in all activities undertaken.

Mr. FAWELL. All right. Thank you.

Mr. ROE. Doctor, I appreciate your comment and I don't feel as if I got an answer to my earlier question that I asked.

One of the recommendations under four of the Commission said that the safety organization—"NASA should establish an Office of Safety, Reliability, and Quality Assurance, to be headed by an Associate Administrator, reporting directly to the NASA Administrator." Do you subscribe to that point of view?

Dr. GRAHAM. Yes, Mr. Chairman. And certainly, along with the other recommendations of the Commission, we'll look at that one very carefully.

At the present, that responsibility for safety, reliability, and quality assurance does lie with an Associate Administrator reporting directly to the Administrator. That Associate Administrator is the chief engineer.

Mr. ROE. Well, what's bothering me a little bit—just so we get clarification for the record, to know where you fellows are coming from—part of the discussion that came from Dr. Fletcher came back and said, well, remember, those things were not specific recommendations or other specific directions; they were recommendations for consideration. In this instance, that's not a recommendation for a consideration. They use the words, "NASA should establish." So do we consider any of these areas where we come down, in the recommendations, where it says "should" as compared to "may" or "maybe" to be something that would have a stronger balance in your thought process—and, boy, am I being sensitive to this issue right now.

Mr. GRAHAM. I think there is a difference in the recommendations in the various areas, and we are paying attention to that. But I would add that we already have an Associate Administrator who has among his responsibilities safety, reliability, quality assurance. I believe the question before us is, should there be an Associate Administrator position dedicated only to those functions? And we'll certainly consider that as we go forward in implementing the recommendations of the Commission.

Mr. ROE. Well, I don't want to belabor it, but I would suggest the point of view that obviously the Commission certainly must have known that, or they wouldn't have put the recommendation in, No. 1. I'd be astounded if they didn't.

I think, No. 2, they're saying that we should be creating an Office of Safety, Reliability, and Quality Assurance. Part of what you were responding to the gentleman from—Mr. Fawell from Illinois—a few minutes ago was based upon your concern with the transmission of safety information through the whole structure, and I applauded that approach. I just want to nail down for the record that there seems to be a hesitancy of saying—are we saying that we've already done that, that NASA has in place an Office of Safety, Reliability, and Quality Assurance that's headed up by somebody? Or is it effective? Why did the Commission recommend that or put it in their response at all?

Dr. GRAHAM. Mr. Chairman, we're saying that that recommendation has, in fact, been in place in one particular form. The fact that it is a recommendation there indicates to me that the Commission is suggesting that that form may not be adequate, and we are going to go back and look at that very hard and make sure we understand exactly what the Commission was trying to get at and what it recommended, and consider that as we go forward. We will give that the most serious consideration.

Mr. ROE. Well, making the point on the record so that when we call you back shortly we'll be looking for what your response is going to be to that.

I thank the gentleman from Illinois.

The next colleague is Mr. Slaughter, our distinguished colleague from Virginia.

Mr. SLAUGHTER. Thank you, Mr. Chairman.

When can we expect NASA to have a schedule for shuttle flights over the next years?

Admiral TRULY. We have a preliminary schedule for the earliest possible flight of July of 1987. During that year, we have already planned that the maximum rate will be either six or seven flights, and that will depend on specifically which vehicles we will fly. I hope within the next few weeks to be able to recommend a manifest for specific flights throughout that period, and it would be available at that time.

Mr. SLAUGHTER. I have no further questions.

Mr. ROE. I thank the gentleman.

The Chair recognizes the distinguished gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. Chairman, I have three questions for this round of questioning.

First of all, I want to follow up in my discussion yesterday with Chairman Rogers and Vice Chairman Armstrong on what we learned when we were with you, Admiral Truly, last Friday down at the Kennedy Space Center on the question of the verification for the contract specifications of how the SRB was to operate under natural temperature and also under the induced temperature. And the contract specs are contained in a document that was prepared for Marshall by Thiokol dated February 17, 1984, in which—the temperatures have been mentioned here earlier—from 99 to 31 degrees, and with an induced temperature that goes down to 25 and, in another case, 21 degrees.

I have the documentation here of the verification that was signed off by all the parties for the flight of STS-1 and then I have the documentation also on the verification for STS-5. What can you tell us that you know about why was this verification given if, in fact, as you and I learned at the Cape on Friday, that testing in fact was not done? What do you know about it? Just share that with us.

Admiral TRULY. I'm going to have to take that question for the record or ask you to ask it again when we have our test team members here tomorrow, that they can help answer that.

Mr. NELSON. Well, let's ask Mr. Aldrich. Since these Level III folks at Marshall would be reporting to you as the program manager, what do you know about why wasn't the testing done?

Mr. ALDRICH. Mr. Nelson, I know very little about the details of the testing and the response between the level 4 contractor organization and the Marshall level III project organization. I have not participated with the task force and have not delved into that in detail. I have researched the feedback to the space shuttle program to the level II from Marshall indicating full compliance with that requirement for induced requirements as part of the certification that was reported prior to STS-1 and has continued forward since that time.

Mr. NELSON. All right. So you're telling me, nobody knows the answer to the question? The question is, does anybody have a clue as to why, under the obligations of the contract, the testing was not done? And why NASA signed off on two occasions that the testing, in fact, had been complied with—the contract had been complied with? Is there anybody here that could address that question now?

Admiral TRULY. No.

Mr. NELSON. OK.

After we heard that on Friday, what did you ask, Admiral Truly, to be done with regard to providing information to you on this particular question?

Admiral TRULY. At this point, I have not asked for any action, but I certainly will, since as you know, at that point we were waiting for the Commission report. I do not know what that task team concluded in its report, or precisely what the Commission staff developed on that issue. But I certainly understand the line of your question, and I would like to take it for the record to supply the answer as best we can put it together.

[Material to be supplied follows:]

Material requested for the record on page 97, line 2191, by Mr. Nelson during the June 11, 1986, hearing.

There are no qualification test specified in the design specifications for the joint per se. There are, however, design specification and verification requirements for the performance of pressure seals and the structural elements (i.e., case and nozzle). The case joint pressure seals are to be redundant and verifiable through an external test port. Natural environment specification, to be certified by analysis, are 31°F to 99°F (JSC 07700, Vol. X, Appendix 10.10). Induced environment specification, to be certified by analysis, are 25°F to 120°F (SD74-SH-0144, ICD 3-44003). The lowest established joint temperature in test was 40°F during one of four demonstrations and three qualification static test firings.

Mr. NELSON. OK. When will those folks that you're talking about attend?

Mr. ROE. Tomorrow afternoon. Tomorrow.

Mr. NELSON. Tomorrow? OK.

The other question that I would like to address specifically on this issue is, since everybody is saying that it was not complied with, in addition to why wasn't it complied with, is there some contractual breach here that we need to know from a legal standpoint? So let's address that.

Admiral Truly, earlier today Dr. Fletcher had indicated again that the earliest possible date that we might fly is July 1987, and I'm wondering about that date by virtue of a report that was given to NASA before you came back to NASA last August, August 1985. It was a Thiokol briefing to Mr. Weeks at headquarters, and it was talking about a redesign of the joints—in fact, putting a capture feature—and it said that "the earliest possible implementation"—and I'm reading right from their report to NASA—"was on STS-81N," which, under the manifest, was scheduled for August 1988. Now, if that report would have said that in a redesign for a capture feature—and this is a report that was given last summer—why do we have reason to believe now that we could come up with an opportunity to fly incorporating some of the same redesign, but to be some 12 or 13 months earlier than what was projected?

Admiral TRULY. I'd like to briefly address that question and then ask again that it might be directed tomorrow to Mr. John Thomas, who is head of our SRM redesign team at Marshall.

We have recognized that in order to get into tests with the new design, we've had to expedite the delivery of the case segments in order to get them into a test program that could meet a flight date whenever it may be. The capture feature is one of the various features that is being considered. The early indication that I have is that alone, probably not an adequate design. But that's what the redesign team is for, to look at the various redesigns.

So I think the specific answer to your question is, we've had to spend money and effort in bringing those case segments forward as quickly as we can.

I should point out at this time that those various case segments that have enough metal to have a capture feature on them are a threat to the schedule of the summer 1987, as is the tooling that is required at the manufacturer's plant to machine them. And we will continue to evaluate those schedules and try our best to meet them, but within the context of what Dr. Fletcher said in his statement, and that context is flight safety.

Mr. NELSON. OK. I'll follow up on that tomorrow.

Mr. Chairman, if I might, the third question that I wanted to lay out here—let me get Admiral Truly's response on this.

In the report, the Commission notes that—

> Numerous contract employees have worked 72 hours per week, and frequent 12-hour shifts.

And then it goes on to cite—

> The potential implications of such overtime for safety were apparent during the attempted launch of STS-61C on January the 6th, when fatigue and shift work were cited as major contributing factors to a serious incident involving a liquid oxygen depletion that occurred less than five minutes before the scheduled liftoff.

You and I have talked about that draining of the LOX from the tank. They're saying that that was due to fatigue and excessive work shifts. Do you agree with the Commission? And if you do, what is the plan for action to alleviate such fatigue in the work shifts in the future?

Admiral TRULY. Well, I must tell you that I've been very concerned about looking at some historical data part of the flight of the overtime that was required in the year and a half or so before the flight. If you plot overtime at the Cape versus the number of vehicles in flow, it was increasing. And I think what we plan to do in the future is to make a major effort to take a look at what a reasonable industry standard is and with our shuttle processing contract down at the Cape, what our actual capability is to make sure that the flight rates that we choose do not require overtime above some level that we choose through study and work to be proper. In other words, we're going to look at the overtime; when we get back to flight, we're going to agree on what the sort of level is, and we're going to manage to that and not allow pressures to increase the flight rate to get ahead of our resources, our people resources, to do those jobs.

Mr. NELSON. Mr. Aldrich, you were right there at the Cape in January. That's sort of an unfair question to Admiral Truly, because he wasn't back with the organization. Do you agree with the Commission statement? And if you do, what do you plan to do about it in the future?

Mr. ALDRICH. I agree with the Commission statement in general, that large amounts of overtime were required for the pace of schedule that we were seeing during the latter half of 1985 and leading into 1986. I'm not sure I would draw that conclusion about 61–C, however; if you will recall, we were scheduled to launch on December 19, and had a problem where we were not able to launch on that day, and the mission team made the decision to wait until after the Christmas holidays, with one of the major considerations being allowing the team to have time off for that period, and pick up again in readiness to launch on January 6. So that might be one of the periods more prone to, in fact, allowing relief and a break for the team, although I'm also sure that maybe specific individuals might have been involved in a way that caused them not to get the full break during that period.

Mr. ROE. In the future, there's no question that that consideration needs to be addressed directly? We understand the work we're requiring the teams to do. And also, the spread across the number of people on the team and make sure no single element of it is overloaded beyond the point of our understanding of the total team schedule. And we'll be looking into that in depth.

Mr. NELSON. If you took this recommendation, Mr. Chairman, to its logical conclusion, it would mean that there would have to be either much less frequency of flights or, as the buildup of the frequency occurs, a greater work force in order to more evenly distribute the workload so that the stress and fatigue factor did not come in here. And therefore, that has imminent budgetary implications which we're going to have to get onto as we get into the authorization for appropriations legislation that's coming on down the pike.

Mr. ROE. If the gentleman would yield, I think that your line of questioning this morning goes in the direction which the Chairman has been trying to direct this, which is the safety aspect. And it seems to me that as we—I know it takes time and a great deal of energy—but as we are developing these specific points, they are all leading towards ultimate policy decisions, funding, priorities, and the points of safety that you're mentioning. So I think your contribution is extraordinarily important; especially having been there, it is very important.

Now, if we would now take our break as we had discussed, and we will return at 1:30 to begin our program this afternoon. I want to thank everybody, and we'll see you at 1:30.

[Whereupon, at 12:33 p.m., the committee recessed, to reconvene at 1:30 p.m. the same day.]

AFTERNOON SESSION

Mr. ROE. The committee will reconvene.

When we took our recess we were in the middle of questioning by our distinguished Representative from Florida, Mr. Nelson, and then we were going to now welcome back Dr. Fletcher, and Mr. Germany, however, has joined us now; right?

So I now defer to Rear Adm. Richard Truly. Begin again, if you will, for the record, to introduce and give us some background on Mr. Germany, and then we'll—and then go ahead and outline what our plan is for—your plan for right now.

Admiral TRULY. Thank you, Mr. Chairman.

On the makeup of the NASA task force, we had six major teams, and one of those teams was the photo and TV analysis team. And Mr. Dan Germany from the Johnson Space Center was the leader of that team.

That team supported the Commission and all of the other teams with all the thousands of frames of individual photography, television shots, and so forth, and has pulled together a short TV look at the accident itself, and I think, without further ado, it would be helpful for me to just turn it over to Mr. Germany and let him talk for a moment with this model of the space shuttle here to my right, and then allow him to narrate the TV.

Mr. ROE. Splendid.

We have Dr. Fletcher and some folks sitting up here to see this film because they haven't seen it before.

Mr. Germany, if you would go ahead.

Mr. GERMANY. OK. Thank you, Mr. Chairman and members.

The photo-TV support team concentrated all of its efforts on taking the products that we received that day from the flight——

Mr. ROE. Would the gentleman yield? This is one of five teams; correct?

Mr. GERMANY. Six teams, sir.

Mr. ROE. One of six teams?

Admiral TRULY. One of six teams. Four of the teams paralleled in a one-for-one relationship the four teams on the Commission.

Mr. ROE. If the gentleman would yield, it might be profitable—I'm sorry to interrupt you—it might be profitable to—for the members of the committee that didn't have an opportunity to visit with you, together with the folks that are here and other witnesses—it might be well to give us a little rundown on the six teams, the six teams that served, because they're going to be testifying, as I believe, some of them, tomorrow, are they not? They will be with us tomorrow. So why don't you just give a quick overview of that?

Why don't you give an overview and then we'll revert back to Mr. Germany so he can pick up this one team, and then we'll have——

Admiral TRULY. Thank you, Mr. Chairman. That might be very helpful.

The NASA task force was organized with myself as the chairman and Mr. J.R. Thompson, who will be here tomorrow, as the vice chairman. I remained in Washington during the conduct of the investigation, and Mr. Thompson was located at the Kennedy Space Center.

As I pointed out a moment ago, we had six teams on the NASA task force. Four of the teams, four of the six, paralleled on a one-for-one relationship the four teams on the Commission, and I'll speak to them in a minute.

We had the two additional teams of the NASA task force. The first one was the search, recovery, and reconstruction team, which was the team that managed the salvage effort to get the actual physical evidence and debris of the *Challenger* from the ocean floor and then examined that physical evidence in large hangars at Kennedy Space Center.

The second team is the team that Mr. Germany headed, which is the photo and TV support team.

The four teams that paralleled the Commission teams were the development and production team headed by Mr. Jack Lee, who is the Deputy Director of the Marshall Space Flight Center. He looked at the development process, the part of the investigation that had to do with the buildup of the solid rocket motors, for example, in the factory.

The second was a team called the prelaunch activities team, headed by Mr. Tom Utzman, who is the Deputy Director of the Kennedy Space Center, and the prelaunch activities team looked at the flow of the vehicle and the buildup of the 51-L *Challenger* spacecraft as it approached the path.

The third team of those four was called the Accident Analysis Team, and it was actually headed up by Mr. J.R. Thompson, as well as his job as the vice chairman of the task force. That was the team that supported the Commission in the elimination of the various problems that were postulated; for example, a problem in the external tank in the orbiter. And, as you know as you read the Commission's report, finally narrowed down the final cause of the accident, which was the fatal joint in the solid rocket motor.

And, finally, the last team was mission planning and operations team, which looked at things like manifesting, workload it caused at the Johnson Space Center, training, things like that.

In tomorrow's hearing we will have each of those team leaders here as well as Mr. Thompson, and Mr. Germany, then, was one of the six key leaders of our six teams.

Mr. ROE. The Chair recognizes Mr. Germany.

Thank you very much, Admiral Truly.

Mr. GERMANY. Thank you, Mr. Chairman.

As the admiral said, the photo team consisted of people from each of the three major centers—Johnson, Marshall, and KSC. We had approximately 100 people including contractors and some photo facilities, processing facilities, outside the Agency that helped us with our analysis of the products that we received that day.

There were roughly 108 film cameras and roughly 69 TV cameras, for a total of 177 cameras from which we got products that we analyzed, and represented about 13 million frames of film.

What I'm going to do today is to narrate a TV film that we put together that is a compilation from several of the cameras that we had. But before I do that, I'd like to use this model to try to orient you just a little bit, so that when you do see the film, perhaps it will be a little bit easier for you to pick some of these things up.

A lot of times it happens so fast on the film it is very difficult to pick it up the first time you see it with your eyes, so a little bit of orientation here——

Mr. ROE. Are you able to—when there is a specific area that you want to highlight, are you able to stop the film at that point?

Mr. GERMANY. We have used stop action with the way we put the film together, and it turns out that that's not——

Mr. ROE. You can?

Mr. GERMANY. I'm going to answer for you.

Mr. ROE. I'm sorry.

Mr. GERMANY. We've used stop action to put the film together. Some of that is stopped as it's moving. If it's not really clear to you, then we can stop it and run it back.

Mr. ROE. OK.

Mr. GERMANY. However, with this recorder we have here, when we stop it, you lose everything and you've got to punch the buttons back and forth. All right. So you may get tired of that if we have to do it, but I'll be glad to.

The model as you know, the shuttle when it takes off—Admiral Truly told me not to pick the model up because he doesn't want me to break it. When the shuttle takes off and flies like so—so this is the righthand SRB, and the points of interest will be the leak that developed was right on this side and around the 300 degree point. Actually when—the recovered hardware that we got back, the burnthrough was from that 296 degrees to 316 degrees, 294 to 316.

So you'll see the flames and the smoke actually come from this part of the vehicle. When you see the film, it will be obvious to you what I'm talking about there.

The other thing that happened, first of all, there are three main segments of activities, I guess you could say, that occurred with respect to the anomalous events we saw with the photography. The first took place at 0.678 seconds when we saw the puffs of smoke that occurred, and you'll see those.

At 0.836 seconds up to 2.5 seconds there were multiple puffs of smoke, and I believe Mr. Rogers mentioned that yesterday when he was here. It was like eight or something like that. And then at 3.4 seconds you stop seeing any smoke. That was the last time we saw smoke.

Then there's a period of time in which there are no anomalous events in the photography. About 58 seconds is when the first flicker of flame appears in the same area from which we saw the smoke. And that goes from a flicker of flame all the way up to a large flame that you'll see that resulted in the LH_2 tank leak which occurred about 64 seconds.

Now, a point of orientation for you: this is the external tank. The lox tank is on top and the hydrogen tank is on the bottom. So that LH_2 tank leak I'm talking about occurred right around here, which is what we call the 2058 ring frame. And 2058 is just a station location as you move up and down the tank. But that's just for simplistic sake we call it a 58 ring frame. That's when the lead occurred, about 64 seconds. And then there's a period of time, about 9 seconds, when nothing really happens that we see on the photography.

Then at 73 seconds into flight, 73.124 to be exact, is when we have an LH_2 tank failure, and you'll be able to see the LH_2 liquid as it comes out.

At the same time this righthand SRB starts to move, because what's happened is either the strut was burned into or we had breach of the tank where it came loose. When it came loose and it moved out this way, and this part of the SRB crushed into or hit the intertank area—intertank means that space between the lox tank on top and the LH_2 tank on the bottom. And when that happened, essentially losing the integrity of the external tank structure, the significance of that is this whole vehicle configurationwise is tied together through this external tank. You've got the SRB's that tied to this ring frame I mentioned. At the far point there's a large truss structure that goes across the intertank area. So when you lose the LH—the ET tank structure, then the whole thing we call structure breakup occurs.

And that—from the point that we saw the LH_2 tank failure, which is 73.124 seconds, then at 73.327 is when structure breakup occurred. So that's only 0.2 seconds or like 200 milliseconds.

OK? So with that, then, what I'm going to do is roll this film, but before you do it—what I'm going to have to do, Mr. Chairman, to help you is I'm going to come up there and use the monitor and to use the mike. So it will take me a second to get my props set up.

Mr. Roe. I understand they have to leave this one spotlight on.

Mr. Germany. We've got that all squared away.

[Pause to begin film.]

Mr. Germany. Let's see. Someone's going to get the lights in the back.

OK, Tommy, are you ready to roll? OK, go.

[Film being shown.]

Mr. Germany. We're starting with the first sequence that shows the smoke.

This is one of the TV cameras. You'll see the smoke coming right there. We're going to show some isolated views in a second so you can see a little bit clearer, but that's the first time.

This is engineering camera 60.

You can see it coming right there. We say multiple puffs. You can actually see it kind of billowing out as it goes. You're going to see that clear in just a second.

OK, this will be a little bit clearer because of the background here. See the black smoke going right there? There you go.

Then it disappears at that 3.3 seconds and then we don't see it anymore.

This is a combination view. Here and here.

This is a data camera that's kind of looking to the side. You can see it.

But we said it moved initially in the plus X direction, meaning it's moving like so.

This is attach point that goes around the SRB to the 2058 ring frame. The joint itself is right above there, right about in there.

This is later on in the flight where we first see the flame development, and we're going to show you several views here. You can start seeing a little bit of the flickering that goes—see right there.

We'll go back and isolate this and you can see it. There are several frames here to give you a perspective of it.

You can't see much from the camera because we purposely darkened the background so it would highlight the flame when it appears. That will show up in a second.

There you go. That's that 58 second point I was talking about.

So essentially what happened, you had the smoke; then it tended to heal itself a little bit; and then later on it started developing. Once that flickering starts, then it gets progressively larger as it goes.

You can see it isolated on this shot over here.

As the flame gets larger, the plume gets larger, the aerodynamic effect makes it tend to move to the rear.

And as that's large enough, what that means is the hole is just getting larger as it grows. Then the whole thing is constant.

And after that occurs, then the flame is impinging upon the LH_2 tank—is what caused the leak to develop.

There right there.

I can see it just getting progressively worse. At that point the R rates here is what helped us to understand that their right-hand SRB was starting to move.

This is a computer-aided design picture here, and what we have done is accentuated the motion and we rock it back and forth. Actually it did not rock back and forth, but that's just to let you get an idea—is that motion I was talking about earlier in the model occurred here.

Then once it started to move away is when it collapsed into the intertank area forward.

You'll be able to see the LH_2 tank failure because the flame will start to look different here.

There you go right there—when it just changed that color there, that was when the tank failure occurred.

This first hint of vapor at the intertank area is an indication that that lox tank on top was leaking after the SRB moved into it; that's right.

These are taken from 70 millimeter frames, and they are clearer on my tape, but when you make it into a TV like this, you lose a lot of the clarity.

Then you can see a flash in here.

Due to aerodynamics, when this hydrogen is leaking here and the lox is leaking here, the hydrogen actually tends to move up the side of the vehicle, and when it did, it combined and then from the heating you got the flash there.

This is what I meant by us using stop action, when we made this, to help you to see it.

This intense white flash is when we believe the total structure breakup occurred.

The greatly increased intensity of the white flash—that was just the way we indicated that was when the structure breakup occurred because it appeared to the large explosion occurred here.

Oh, the vehicle came apart. OK, the SRB's and the orbiter and the ET just all came apart.

We call it structure breakup rather than a real explosion because a lot of people argue whether or not it was really technically an explosion, but we know it was structure breakup.

What this series of frames is—this goes back and repeats what you've just seen.

You're going to see the chute here in a second and nose cap, the right-hand SRB. There's that nose cap going. It'll stop here in a second.

There's the chute and there's the nose cap there.

Then you're going to see range safety destruct to the right-hand SRB, and then on the left in a second.

Here's the left.

Now you're going to see a frame of them side by side a little further distance away. Here and here.

It was going out of the limits that the range safety officer had, so he went on and destructed. It turns out it really helped, because if those things are burned to completion, they probably would have been out in such deep water it would have really been tough for recovery.

[Film stops temporarily because projector is unplugged.]

Mr. GERMANY. Tommy, would you stop that and just back up for a few frames because I want to get the header of this? Just push rewind and just—Mr. Chairman, stand by. We're going to have to replace on this because I want to see the first of this.

OK. Because of the interest in the crew cabin, we've included some filmage here. You're going to see this several different sequences, so we'll start with the larger picture first and then we'll zoom right in on what we're able to see.

There's some pieces that were coming out here. This was the wing that was going off in that direction.

We'll zoom it back in in a moment, but in the second smoke trail is where the crew module ended up going. We're going to show you some details of that.

This is from camera 202.

It's going to be coming right through there. I'm going to show you some more details in a second.

This one right here is the one that did the dipsy-doodle which was left; right?

Now when we did this, we took some TV and enhanced in on a frame-by-frame basis.

That was not it right there. No, it was another piece.

Coming up. See, right there? It's going to cross through that smoke in just a second.

There it is right there. OK? We think this is the remainder of the SS and these burning in the aft compartment there.

Mr. BOEHLERT. How did you identify it? Did you enlarge the frames?

Mr. GERMANY. These have been enlarged a little bit; yes, sir.

You can see it a lot better on a light tobe when you have a 70 millimeter, and it just stood there and just stayed at it for a long time.

Now it's coming down here. That's the crew compartment, yes.

In a moment you're going to see one more series. It looks like it's moving up, but that's just the way we did it when we put it together. It's actually not moving up, but this just gives you an idea of what it looked like.

And that completes the film, Mr. Chairman. In fact, that completes what I've got for you today. I guess tomorrow we're going to use a cam line, and the cam line I can show you what's happening on the vertical side as well as from the photography point of view.

Are there any questions?

Mr. ROE. Well, does any particular member have any questions on this particular issue at this time?

The gentleman from California?

Mr. PACKARD. Just one came to my mind. Is there any significance as to the black puffs of smoke, the color of the smoke, because there was black and white smoke together there?

Mr. GERMANY. The color of the smoke would tend to indicate there's hydrocarbons burning which could represent the erosion of the O-ring that's taking place as well as there's grease in there as well.

OK. Thank you, Mr. Chairman.

Mr. ROE. Thank you very much, Mr. Germany.

All right. Well, we want to welcome you back, Dr. Fletcher and your other colleagues. And I think that was a very descriptive presentation made that helps the members a great deal to understand the sequence of events which I'm sure will be helpful when we get into the additional questions and answers.

Now we had just finished before lunch with Mr. Nelson—I'm sorry, Mr. Nelson from Florida, and now we have our next colleague, Mr. Valentine from North Carolina.

The gentleman from North Carolina is recognized.

Mr. VALENTINE. Thank you, Mr. Chairman.

We have had to leave here so often and we've been in and out, and this might have been covered by your——

Mr. ROE. Will the gentleman pull the microphone closer, please.

Mr. VALENTINE. This might have been covered by your testimony. If so, I apologize, but we are discussing the findings of the Rogers Commission, and I would like to know whether or not there is now or has been an ongoing, internal investigation by NASA and—or if, after the Rogers Commission was constituted and went to work, whatever was contemplated in that area kind of merged with the Rogers Commission. That may be more than one question, but——

Admiral TRULY. NASA did participate fully in the investigation as a part of the NASA task force and those six teams that I described a few moments ago in support of the Commission.

All of our investigation was done essentially in their support. We met with them many times. I'm not aware of another internal investigation that has gone on. Naturally during the progress of investigation there were thousands, literally, of things that were looked at, but it was done under the NASA task force in support of the Presidential Commission.

Mr. VALENTINE. So what you're saying was that what we have at this point is one investigation, that there was not any kind of parallel effort?

Admiral TRULY. That's true.

Mr. VALENTINE. I'm not talking about whether or not there was an effort to look at problems of communication, the things that have been addressed here, but whether or not there was another internal investigation of the tragedy, the explosion, that might have reached a different conclusion or might have been compatible with the results which have been explained, or if there was anything of that kind that might be of interest to this committee.

Admiral TRULY. No. I would say that it was a single investigation conducted by the Commission. There were many parallel efforts as we chased down possibilities of failure as the weeks went on. There was plenty of technical controversy as we got more and more data. For example, the film that you just saw was not all developed in the first day or looked at. It took many, many weeks. But, nevertheless, those were all facets of one investigation that came to the answer as reported in the commission's report.

Mr. VALENTINE. Thank you.

Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes Mr. Lewis from Florida.

Mr. LEWIS. Thank you, Mr. Chairman.

Dr. Fletcher, I think you're going to have some very trying moments over the next few months, but I'm sure you'll be up to the challenge. I think it's excellent that we see those who go out on a razor's edge—Admiral Truly and Captain Crippen—in the positions that they're in.

I was reading U.S. News & World Report, and you probably saw it yourself, and talking about what you're going to be doing and that you're an interim director. I think anybody that takes over the administration of NASA is an interim director. They're not going to stay there forever.

But how are you going to be able to cut through the layers of bureaucracy and really get to the meat of some of the problems? What is your plan on doing that?

Dr. FLETCHER. Mr. Lewis, I didn't use the term "interim director." I think that was the newspaper's term. I plan to stay the remainder of the current administration.

Dealing with this problem is not a trivial matter. This is a very complicated piece of machinery. We have a very large team of people that are involved in putting NASA back together. It's not only the 20-some-odd-thousand NASA employees, but there are all the contractors that we work closely with. That's going to take some weeks, months, and probably the full 18 months' delay that was caused by the accident to deal with it.

I know of no better way, Mr. Lewis, than to talk to the people at middle management levels, at top management levels and, to the extent that it is possible for an administrator, talk to the people who are at the working level. That, as you know, is difficult to do, but, nevertheless, somehow or other you've got to feel you know how the troops are feeling, because motivation is a key element in making this complicated piece of machinery work, and it's important that by the time we fly again the team is properly motivated.

Mr. LEWIS. Do you plan any shakeups in this point in time? Are you going to get a new broom and do some sweeping?

Dr. FLETCHER. Mr. Lewis, we'll do whatever is required to make the management team and the whole organization function better. When people need to be replaced, we will replace them. When we need to reorganize with different people or the same people, we will do that. It will happen not all at once, but we'll be observing it as time goes on and we'll keep you informed as we do it.

Mr. LEWIS. In the Rogers report it points out that you should have some sort of quality review and quality management, and I'm just wondering if you're looking to have a quality review and design review board with the head of that board that can get directly to you, as the report suggests, by either an Associate Administrator or what have you, and cuts through the lower levels of management, either arc them or go straight through or sit on the boards, someone, say, like Admiral Truly or Captain Crippen or someone that has been there and knows that something must be done, so they don't have a lack of application on quality tests and things of that nature or redesign and they can get to you.

Dr. FLETCHER. Mr. Lewis, that, of course, is going to be one of Admiral Truly's high priority items to look at all of the safety, reliability, and quality assurance aspects, and I'm sure he's going to have such groups reporting directly to him.

In addition, as you probably know, SR and QA, as we call it, reports directly to the Administrator. And we have such a group now. The important thing is that they're able to get the information from where it is necessary to come, and so the free access to that safety board will be possible.

In addition to that, as you know, we have a statutory safety review board which was set up after the Apollo fire in 1967, and that also reports to the Administrator. Both of those functions will have to be tightened up considerably from my point of view, but I imagine Admiral Truly will want to do the same for his part of the organization.

Mr. ROE. If I could ask you to suspend at this point, we'll return in about 15—10 minutes. We'll recess for 10 minutes.

[Recess taken.]

Mr. ROE. Today we'll reconvene.

When we recessed to go to vote, we were having a line of questioning being presented by the gentleman from Florida.

The gentleman from Florida, please?

Mr. LEWIS. Thank you, Mr. Chairman.

I would like to ask Admiral Truly a couple of questions about the role that Captain Crippen will play. You mentioned that he will head the Shuttle Management Review Board for the various agencies or various groups. Is that what his title will be?

Admiral TRULY. I don't know what his title will be. I haven't figured that out yet, but specifically——

Mr. LEWIS. Well, will you clarify what his role is?

Admiral TRULY. Yes, sir.

There are two specific Commission recommendations. One is the second one which deals with shuttle management structure, and the second, which is No. 5, involves improved communications. Those are complicated issues that I'm going to have to decide what recommendation to make to Dr. Fletcher so that we can do two things: first of all, look at the total shuttle program management structure and revalidate that large portion of it that I'm sure will be revalidated, but change and streamline a portion, if necessary. I need someone to help me pull that together, and it is specifically that that I'm going to ask Captain Crippen and whoever he needs to help him to pull together the options and look at it and see where the system could be made better.

Mr. LEWIS. I see. Do you have any idea at this point who will be working with him?

Admiral TRULY. We have not selected individuals. But I would rather have a small group of maybe three to five people that would be the core group, so that they wouldn't be a large committee. However, they will have full access not only to all the management within the shuttle system and our centers, but also people outside the agency.

Mr. LEWIS. I see. Will there be people from Marshall? Will Marshall have representation on this team?

Admiral TRULY. We just haven't selected the individuals that will help Captain Crippen do this task. However, the Marshall management team will certainly be a part of the review as he goes around and takes a look at what we have now and where we ought to go.

Mr. LEWIS. How will Crip's activities interface with what General Phillips' activities are?

Dr. FLETCHER. Well, General Phillips is going to look at the overall NASA agency, and it's anticipated that when the time comes and Crip's task force is put together, they will interact frequently. But, of course, it's more important that we get on with the shuttle management and communications aspect. That's why the first task is what Admiral Truly described—get on with the shuttle communications and management. We haven't quite got to that point in General Phillips' review.

Mr. LEWIS. I see. One final inquiry for Dr. Graham: Dr. Graham, you partially answered this this morning, and I'm interested. Now that you have been associated with NASA and you're going over to the Office of Science and Technology as the President's advisor, how do you visualize your role now and working in intra-activities with NASA, with Dr. Fletcher and Admiral Truly in getting this program moving and back up in the air—space?

Dr. GRAHAM. Mr. Lewis, I have not yet focused on the specific actions that I would undertake if I'm confirmed to that job. However, there has been a strong working relationship between the Office of Science and Technology Policy and the Science Advisor to the

President in the recent past while I've been at NASA. I would like to continue that close working relationship and strengthen it, certainly in the scientific and the technology area where it's historically been. But also try to maintain a close cooperation with NASA in the area of the larger U.S. Space Program to return to spaceflight and moving forward with NASA generally.

Mr. LEWIS. Thank you, Doctor and gentlemen.

Thank you, Mr. Chairman.

Mr. ROE. OK. The Chair recognizes the distinguished gentleman from California, Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

And welcome, Dr. Fletcher.

Dr. Fletcher I wonder if you could maybe put me at ease a little bit. You've been quoted as saying if the U.S. Space Program is in turmoil, most of the chaos is external to NASA, and here we are in a position of having to sort of look at ourselves as Congress, inward at NASA, and wondering whether we have the ability to reform ourselves, and I'm just wondering whether or not I'm maybe unduly alarmed in terms of taking a statement, and am I taking it out of context or am I saying—when you say that most of your chaos is external to NASA, I'm just wondering whether or not I'm being unduly alarmed about your statement.

Dr. FLETCHER. Mr. Mineta, I don't remember having made that statement, but it's probably true that, if it were made, it was made before I was nominated for the job.

Mr. MINETA. This was in last week's Newsweek.

Dr. FLETCHER. Oh, then, I don't remember making that, but let me go on and say that there is not chaos within NASA. There's some uncertainty, as you might expect there to be. We are undergoing management reviews and probably management changes. People are uncertain as to when we'll be able to fly safely again. People are uncertain about when their missions as scientists, for example, will fly again. So I would say rather than chaos within NASA, it's uncertainty, and there is some evidence that we need to reassert our goals within NASA, and we are in the process of doing that.

Mr. MINETA. You're not saying, then, that NASA's OK but the chaos is external to NASA?

Dr. FLETCHER. I don't remember saying chaos, but I can't really speak for the outside world, Mr. Mineta.

Mr. MINETA. The office of—is it Safety, Reliability, and Quality Assurance that's now being talked about to be created within NASA? I believe that's been recommended by the Commission.

I'm just wondering whether you've had an opportunity to take a look at this, as to whether or not this might be—this recommendation is going to be accepted.

And I chair the Aviation Subcommittee for the Public Works and Transportation Committee. The FAA, for example, has an office for airline safety and creates standards for airline safety, but it doesn't try to fly the airplanes or adhere to schedules or make money. And I'm wondering if this internal office is going to be insulated from the kind of, I guess—or the relationships that that would have, that office would have with other parts of NASA to be able to be really an office of Safety, Reliability, and Quality Assurance.

Dr. FLETCHER. Mr. Mineta, that's an extremely important function in NASA. The Safety, Reliability, and Quality Assurance Program is currently under the chief engineer, and reporting to him are the Safety, Reliability, and Quality Assurance directors of each of the centers. We think that whole process needs reviewing. It's important how well it's done and to make sure that communication channels are good and that people at both the receiving and sending end of those communication channels are competent, and it's competence and good judgment that counts in reliability and quality assurance. And we will certainly take a look at that whole program both NASA-wide and also within the space shuttle program, and that will truly, undoubtedly start our enthusiasm already.

Mr. MINETA. Among other findings of the Commission, they stated very explicitly that the Thiokol management had reversed its position and recommended the launch of 51-L at the urging of Marshall and contrary to the views of engineers in order to accommodate a major customer. Elsewhere the Commission talked about the sluggishness on the part of Thiokol in addressing the O-ring problems, notwithstanding memos from engineers and even from NASA itself on other occasions. And it's only in the aftermath of the accident that we're getting the sense that Thiokol is devoting total commitment to this redesign and only now are projecting the can-do attitude about fixing the SRB's.

I'm wondering, is it possible that we have a morale responsibility maybe to look elsewhere for the redesign and the resupply of the SRB's given Thiokol's interest in making the SRB's, and I'd say to the extent of even making money over safety, given some of their actions since the accident that I would even call unrepentant attitude, and so—and also because of what they've done to their two dissenting engineers who testified before the Rogers Commission.

And I'm just wondering whether or not we should be looking elsewhere for the redesign supply of SRV's.

Dr. FLETCHER. Mr. Mineta, you probably know we have asked the National Academies of Science, a body called the National Research Council, to form a very high-powered task force to not only review the various ideas or suggestions for design, for improvement of the seals, but also to certify that the tests on whatever designs we come up with are adequate and they're going to follow these tests as we proceed over the ensuing months.

By the way, I should say that, in addition to Thiokol, we have people at Marshall, from the Johnson Space Center, and probably other places that Mr. Aldrich and Admiral Truly will want to mention, all involved in that redesign effort. So it's not just Thiokol that's involved. I guess the expertise of the entire Nation is involved in that redesign.

Mr. ROE. Will the gentleman from California yield?

Mr. MINETA. Of course.

Mr. ROE. As we have been unfolding our hearing process, without too much reiteration, we spent yesterday analyzing and digesting the response from the Commission, and then we've invited you folks to come in today to bring us up to date as to what your plans are, where you're at, and then specific questions that are being asked by different members. But obviously there's certain areas where the committee has concentrated on in their observations, such as the safety area, the assurance area, the critical items list, and so forth and so on.

I think that the key is safety, as was brought out by so many members—and now I believe that Mr. Mineta is striking at a very important point that has to be aired, in my judgment, and I'm sure the rest of the members, publicly. And I think it's important for me to interject at this point what our plan is after we review with you tomorrow and bring us all up to date on the technical task force working.

Starting next Tuesday, our plan is to start to bring in outside witnesses; namely, the manufacturers. And I think it's a fair comment to say at this point the first one we plan on calling on Tuesday is Thiokol. Now Thiokol centers upon the whole O-ring issue and the whole joint issue, I should say. But as the gentleman from California is developing, whether we agree or not and without trying to pin blame, because that's not what the Commission did nor is it what the committee intends to do, certainly not at this point, it seems to me that the response from Thiokol, their observations, what happened on the way to the forum, so to speak, and what they've been directed to do as of now, is an extremely important, vital point of the whole issue that we're speaking to, not only from the accident point of view, but down the road—where do we go from here; what is our next step?

But that also intimately relates to the Marshall Center, as I understand it, because they're the ones who are the overseers, so to speak, and working on that issue. Now I think what may be very, very profitable would be—there's an old saying that's written that I have on my wall in my office, and it says that more mistakes are made from lack of facts than from poor judgment. More mistakes are made from lack of facts than from poor judgment.

I think it would be to the advantage of the committee, which we'll take up amongst ourselves a little later on, to consider bringing in the Marshall Space key people, technical people I'm talking, engineering people, at the time that we are interfacing with the Thiokol Co. I think that might be extremely profitable, so that we can get this matter up on the deck, No. 1, upfront, and deal with it; first of all, to dispel any lack of facts, bring the facts forward as they are—if the gentleman would yield further from California——

Mr. MINETA. Absolutely.

Mr. ROE [continuing]. Which is the process I believe you're following, so that there can be a response in both directions on that issue, rather than a time lag and all kinds of conjecture or false concerns, or whatever, emerge. Does that sound reasonable?

Dr. FLETCHER. It sounds quite reasonable, Mr. Chairman.

Mr. ROE. Yes; well, then, I just wanted to make that point, if the gentleman will yield further. So that is the direction I would choose to go next Tuesday so that you can develop in more depth your whole line of questioning.

I thank the gentleman for yielding.

Mr. MINETA. Mr. Chairman, if I might, I'd like to ask a little more about the relationship between contractors and NASA. One question I have in this regard is this: Is there a standard operating procedure pertaining to the launch readiness procedures that was woefully ignored in the case of 51-L and perhaps many times before?

In the case of the SRB's, Thiokol was talking to level III people in NASA. On the other hand, it appears that Rockwell was talking directly to level II people. Moreover, Thiokol was asked for a written affirmation of their consent to fly; Rockwell was asked for no such assurance. And it's unclear to me if anyone spoke to the external tank contractors about the ice situation or, if so, what was the procedure at the time.

And I guess what I'm asking is, Are there procedures which need to be established or perhaps have to be newly adhered to in order to make this process less erratic and, frankly, more importantly, more reliable?

Dr. FLETCHER. Mr. Mineta, I'd like to start to answer that question because it pertains to what we're really not doing very intensively, and then I'd like to ask Admiral Truly and his associates to respond to the specific point.

Obviously we've got to tighten up our procedures and, when we say communications, we mean communications and procedures. Communications have to fit procedures, and vice versa. You can't communicate one way and your procedures say something different. That has to be tightened up all up and down the line, from the lowest level to the highest level.

Having said that, I think Admiral Truly will have to answer, but we really have just started that process, and that's one of the reasons that Captain Crippen is here today.

Dick, do you want to——

Admiral TRULY. The review that you have suggested and Dr. Fletcher referred to is the very reason that when I wrote into my strategy for returning to safe flight under what we're going to do in a program management context, I specifically wrote in there that we were going to review a number of things and put in the words "including the launch commit process."

Certainly, looking to the future, we're going to have one system, which I frankly think that we do now, and I'm going to ask Mr. Aldrich in a moment to describe it, although he was not a part of the task force that did the investigation, but he at least I think can describe that process very clearly.

But I can assure you that for the future that we're going to have one procedure used by everybody and known to all.

If I might ask Mr. Aldrich to comment about what the process and what the requirements are today, I would like to do that.

Mr. ALDRICH. Mr. Mineta, we spoke earlier about some of the formality in this area in our review that we would add, including recording and including a more formal list of people for each type of meeting.

The process, as it has worked up to now, however, is documented and is fairly clearly laid out in terms of responsibility. The flight readiness review process starts within the contractor, which could be called level IV. It's the contractor for each element of hardware who does its own internal review of flight readiness and then reports to a similar flight readiness review at level III, which is the individual center project elements.

A level II review commences following that at the program level where each of the projects reports their readiness, and it's finally culminated in a review to Admiral Truly, the Associate Administrator for Space Flight, in a level I flight readiness review, and at that time there are formal, documented signoffs by both the NASA project elements involved and the contractors with regard to readiness, including any constraints or ongoing work in addition to the detailed presentations to describe their readiness. That's about 2 weeks before launch.

And then either 1 or 2 days prior to launch there is a final meeting to tie off any loose ends or to look at any new developments that have occurred. That's normally called the launch minus 1-day meeting, but it might on some occasions be launch minus 2 days.

There, again, there's a formal presentation by each of the projects to the combined levels II and I management, and at the end of each of those presentations there is again a signoff that says the contractor and the project element is ready.

Downstream of that review there is then an operation put in place as the actual countdown proceeds where issues are brought forward to unscheduled but planned-for and documented procedures which constitute an organization called a mission management team with formal membership. Those meetings are the ones which are characterized in our earlier discussions as perhaps not having the formality that we would like to see in the future. Although they are formal meetings, they are not recorded and there are not usually additional signoffs involved. Specific issues that come up, as they are required to be treated, are treated as close to real time as is possible by that group.

And each of the discussions you mentioned with the two contractors were treated in these mission management kinds of sessions, although the one with Thiokol was at a meeting at level III and was not really involved with the total team as I've described it here.

Mr. MINETA. Mr. Chairman, if I might ask very quickly——

Mr. ROE. The gentleman from California?

Mr. MINETA. It appears that the information flows upward in flight readiness reports, as you've mentioned, as those are abbreviated because of the closeness of launch time, but is there a mechanism between launches where past readiness reports or past problems are reviewed in order to demand accountability for efforts to fix recurring problems or to explain repeated waivers?

I get the impression that information only percolates upward at the will of middle management people without corresponding accountability operating in reverse.

Mr. ALDRICH. Could I answer that one also?

Dr. FLETCHER. I think Mr. Aldrich should answer that. On the other hand, Mr. Mineta, I want to remind everyone that information has to flow both ways. Communications is a two-way system.

Mr. MINETA. That's my point.

Dr. FLETCHER. The procedures are written in one way, but this is a collegial, if you like the system that we work in. Unless all members of the team at levels I, II, III, and IV respect each other and communicate well with each other, this system won't work well.

Now having said that as a broad generalization, I'll turn to Mr. Aldrich for the specifics.

Mr. ALDRICH. The specific answer to problems that occur in tracking from flight to flight, we have a formal and, again, a documented structure for the process which logs every flight pre- and post-flight anomaly which occurs with each of the elements. It tracks that element or that problem to a resolution by the project element. It is then signed off at that level and brought forward to level II again for signoff. And for each flight, those that are not closed from the past flight are reviewed and specifically identified.

So, again, the intent is strong that we, in fact, do have a process of the kind that you brought up, and we will certainly be attempting to strengthen that as we go forward also.

Mr. ROE. Will the gentleman yield again?

Mr. MINETA. Of course.

Mr. ROE. You, know, again, I don't like to monopolize other members' time, but one of the key issues that is gnawing at many, many people in the process is, How could it possibly be that the information did not get up to the higher levels? Therefore, somebody had to make a decision in between. They didn't either consider it important or they felt that they had the authority at that level to make that definitive decision. It's just extraordinary that the top of the heap didn't know. And that's what gnawing at us.

And I think what the distinguished gentleman from California is developing is not only a two-way street back and forth, but should there not be a mechanism in management that demands a two-way street where management at top is also asking, or is management waiting for memoranda to come up through the lines to be checked off, and so forth. I don't mean to simplify it.

And I think that if you could give us—if the gentleman would yield further—just a little bit of your overview there—we're really coming back and saying there's got to be some methodology that devised in management where management can handle particularly that kind of a issue. Is that reasonable?

Dr. FLETCHER. Mr. Roe, if I may interject, Admiral Truly, at least as long as he's Associate Administrator for the Space Transportation, is not a shy person, and he is going to ask questions all up and down the line both before the launch and also in between launches.

Mr. ROE. But that's now, you see, and we're glad that Admiral Truly is with us because we have a shoulder to rest on. I'm looking as to what happened before Admiral Truly got here.

Dr. FLETCHER. Yes. I just wanted to assure you that in the future you will have two-way communication, and I and Admiral Truly will see to that.

Mr. ROE. But someplace along the line there's got to be review. As you know, we're going to be looking into that to see what progress we're making.

The gentleman from California.

Mr. ANDREWS. Would the gentleman yield?

Mr. MINETA. I'd be pleased to yield.

Mr. ANDREWS. I'd just like to follow up, Dr. Fletcher.

I think what concerns us, all of us, is that we've seen this report and it apparently—the finding and conclusions of the report is simply that information seemed to flow freely down from the top from levels I and II, but in rare circumstances did it flow the other direction. And I think all of us would like to get a sense of your view of that conclusion. What specifically do you think was wrong with the decisionmaking? Is that a conclusion that you agree with?

Dr. FLETCHER. I have not participated in this back and forth with the Commission. I've read the report.

Mr. ANDREWS. But what is your view of the report?

Dr. FLETCHER. It is quite apparent after reading the report that there was some failure in communications somewhere along the line. Just where it was and how it fit procedures, and so forth, I'll have to leave to the people that were involved at the time, but——

Mr. ANDREWS. You do not have an opinion as to where that breakdown took place after reading the Commission report?

Dr. FLETCHER. I would like to reserve that opinion until I've learned more about it. This is my fifth week on the job and I have talked to the people on the Commission, and I've talked to our own people. I haven't visited the Marshall Spaceflight Center.

Mr. ANDREWS. Do you agree with their conclusions?

Dr. FLETCHER. Yes, I agree with their conclusions.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Wisconsin, Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

I am particularly concerned that NASA has not been insistent that contractors comply with the specs in the construction of various items in the shuttle, specifically the solid booster rockets.

We've seen some information that there was specs relating to ambient temperature that have been completely ignored by Thiokol, and also the gentleman from Florida, Mr. Nelson, came up with information that Thiokol claimed to have tested the solid booster rocket at 21 degrees when in fact that was not the case.

What do you intend to do to insure that the specs are complied with in the future?

Dr. FLETCHER. I think I'd like to turn to Admiral Truly in a moment. I only became aware of that statement today.

The first thing we need to do is take the statement in the context in which it was given, and then we need to respond in some depth because that's a serious allegation.

Mr. SENSENBRENNER. Before Admiral Truly responds, the Armed Services Committee has been frustrated repeatedly about the DOD not requiring defense contractors to comply with specs, and it ended up that they got so frustrated that the DOD authorization law was amended to allow for outside testing of new weapon systems that were delivered to the Defense Department. I think that unless this committee gets some assurance that NASA is going to require that the specs be complied with, we ought to consider legislation similarly to take the spec compliance from you and have someone from the outside make sure that the contractors are delivering what they're supposed to be delivering.

Dr. FLETCHER. Mr. Sensenbrenner, we are going to see that the contractors comply with the specs. I think that the specific instance that you mentioned we really have to research further, and I don't know to what extent Admiral Truly's people have looked at that particular item, but we insist on strict compliance with the specs with our contractors.

Mr. SENSENBRENNER. Well, obviously something big fell through the cracks as far as the solid booster rockets are concerned, and I hope that doesn't happen again.

So, Admiral, why don't you tell us how it won't happen again?

Admiral TRULY. Well, I can only echo what Dr. Fletcher said. I can assure you as part of our review of every critical item on the shuttle program, we are looking at design requirements, the testing history, the flight history of that particular article, and it is absolutely necessary that when we have a program requirement that an item is tested to a certain temperature or to a certain condition, and certified that way, that that in fact is the case and we will undertake whatever effort that we have to to assure that.

Mr. SENSENBRENNER. Does that mean telling the contractor that, "You didn't comply with specs and go over and do it again at your own expense."?

Admiral TRULY. Sure. I mean, whatever it takes. Let me also say that I'm not personally familiar with this particular point that was apparently developed by the Commission's investigation. I'm going to get familiar with it as quickly as I can. Until I do, I would have to say that you have not heard all the evidence from the Marshall Space Flight Center which ran that level III or from the contractor. We certainly deserve to hear that, and we will get there. But for the future, I can assure you that we will have launch commit criteria that we know that the certification is proper.

Mr. ROE. Will the gentleman yield?

Mr. SENSENBRENNER. I yield to the gentleman from New Jersey.

Mr. ROE. As the afternoon progresses after morning, people appear to become a little tired, a little testy, and neither is the case here.

What the committee is interested in developing is the earlier discussion—if the gentleman would yield—that manifested our concern with the critical items, the 1 items and the 1R items. And in our course of discussion this morning we made the point of view that—and Admiral Truly did very well on that, and so did Dr. Fletcher—that there's just no question about rehashing. We're going to see that those particular elements are thoroughly reviewed from top to bottom. We have—you've already vitiated and negated all of the waiver system, and so forth. I applaud. I think that's fine.

One of the questions we came back and said, however, that developed from other folks was we were concerned—I believe it was Mrs. Schneider from Rhode Island—made the point of view that it appeared that there was a substantial reduction in the number of quality control people, at least numerical bodies. That doesn't necessarily mean that that's denigrated or reduced the quality control. There may be parts that you don't need anymore. We respect and understand that. But it was rather a substantial drop.

Now the gentleman from Wisconsin is developing the point of view—it's an extremely important point of view which I think you ought to use the advantage to expand upon technically. I'm going to ignore that.

Mr. SENSENBRENNER. Thank you.

Mr. ROE. That's all right.

Now the point then goes to the point of view that if contractors—and we don't know how widespread this is—if contractors are not meeting their requirements that are under their contract that they agreed to, then obviously they are—I don't want to say defrauding the Federal Government, but they are if they're not producing goods. If I'm asking for a bone, I don't want a dog. I mean, that's what I'm paying for and that's what I expect them to deliver to me, and I don't mean to be facetious, which leads to this point—if the gentleman would yield further:

How widespread is that? If I'm going to come back and I'm going to inspect a critical part 1 and I'm going to say we're going to review that whole thing, query, if I find any fallacies in the—not the design—in the manufacturing, did that manufacturer meet the requirements that initially were put on that product or that part or piece—to meet the requirements that NASA required.

Now you ought to come back and say to us the following, if I may. You ought to get into the discussion we're moving in that direction. We're not sure how far that went. But, however, if we're constantly called upon to provide upgraded and improved parts to get from critical 1 to critical R1, or whatever the case may be, or get the very best part we can, we're changing the terms and conditions and the specifications. Is that reasonable to say?

If I have piece A that is not totally A No. 1 and we found that we shave that a little bit or put a little more candor in it, it's going to be a better piece, then you have to issue a new specification—is that not correct—for somebody to make that part? Do you understand where I'm coming from?

Dr. FLETCHER. Mr. Chairman, I think I understand what you're saying. And, of course, that's the whole purpose of the reliability and quality assurance [R&QA] organization, that we have, which consists of not only our own R&QA, but we have contract monitors and DCAS is done sometimes. That's a Defense Department organization. But whatever is the case, it's absolutely necessary not only that contractors comply with the specifications, but that we know that they comply with the specifications.

In addition to that, your second point is, if we change the specs to tighten it up or to loosen it, as the case may be, we have to make absolutely sure that that contractor complies with that changed spec. That's part of the R&QA——

Mr. ROE. But come Tuesday morning we're going to go beyond the Government's—Commission's and the Government's representatives of NASA, including this committee, and we're going to be calling in the private sector. The private sector has already been convicted in the press. They've already been convicted in the press. Who was the bad guy?

Now it's essential for us to be able to assure the credibility of the future of the space program, but where all of the facts are involved, they must be on the table. And what we're—and I'm not admonishing you or being pedantic, and I think that the question of the gentleman, the line of the questioning of the gentleman, is very important.

Thiokol is the bad guy. That's what's out in front on the deck right now. They have a right to defend themselves in the heart of public opinion and what the facts are—is the reason we want the Marshall people in here, too, at the same time.

Now the evil that's floating here is—and yours, because of a document to that particular company, that they did not meet the plans and specifications that they were chartered to do and paid to do. That is what is before us, which is what people have been alluding to.

Now the gentleman from Wisconsin comes back and he expands on that because, if there is one area that the specs haven't been met, clearly have the specs been met in all the areas? And then the question is—it's not that we're going to do better. What specifically are we going to do to deal with that, because if the specifications aren't being met, and that's the finest bit of engineering on the part is made from the engineering, and those specs aren't being made, we have immediately denigrated the safety factors involved.

So what—if the gentleman will forgive me further—what the gentleman is simply saying is someplace—I hope by tomorrow or when we continue on—that we will be able to ferret out that process. And is there anything we're planning on doing to determine how wide a range this idea of not meeting specifications has gone? Is it in every area? Is it just in that area? It leaves a doubt—is where I'm trying to come from.

Dr. FLETCHER. I think you're right, Mr. Chairman. The first thing we have to do is ascertain the extent of the specific error that was made. Of course, as you properly point out, we need to look at the whole system to make sure that there aren't a lot of errors, if that was one, similar to that one.

Mr. ROE. The gentleman from Wisconsin?

Admiral TRULY. Mr. Chairman, Mr. Aldrich would like to make a comment, if he might, at this point.

Mr. ROE. Yes; of course.

Mr. ALDRICH. In that specific regard, one of the actions for returning to spaceflight that Admiral Truly had in his direction to the program and which we have acted on is a complete review of design certification for each element of the space shuttle program. That is in process now at each of the contractors and each of the project elements at the NASA centers, and it is a detailed review of every element, what the requirements are and how those requirements were verified to be met, either by test or analysis, whichever was appropriate.

In addition, we're also reviewing the environments that the shuttle must fly through and be exposed to, as they are the basis for establishing the design requirements for the hardware. So a parallel activity also in process is revalidating and reaffirming the induced environments and then the process at each element, contractor and NASA, to verify that the design certification is in fact still valid, based not only on any changes that might have occurred, but, as Admiral Truly pointed out, we now have a number of flights of experience in the performance of the specific hardware, and factoring that into the analysis as well.

I think this is an important piece of the total amount of work we're doing, and it's complementary to the critical items list review which I discussed earlier.

Mr. BOEHLERT. Will the gentleman yield?

Mr. SENSENBRENNER. May I reclaim my time? I have one more line of questioning I would like to pursue.

Mr. ROE. *The gentleman from Wisconsin has the time.*

Mr. SENSENBRENNER. Apparently the Rogers Commission is not all that trusting of NASA, at least insofar as the redesign of the solid rocket motor to make sure that the specs are complied with and that the safety factors are adhered to, because on the bottom of page 198 of the Commission report it does specifically suggest and recommend independent oversight in terms of the design recommendations and the effort that the Commission has suggested in terms of the SRM's.

Does NASA intend to have independent oversight as the Commission has suggested?

Dr. FLETCHER. Mr. Sensenbrenner, we have set up a team appointed by the National Academy of Science and Engineering, which we call the National Research Council, headed by Dr. Guy Stever, one of the officers of that organization, and they have been busily involved in helping with the redesign of that seal, I would say, for the last 3 weeks. We've got advanced warning of that particular recommendation and have implemented it.

Mr. SENSENBRENNER. I don't think that that's what the Commission had in mind—that the National Research Council would be in on the redesign, because, you know, that makes them part of the team. I think what the Commission had in mind from reading the paragraph that's in the report was that after the redesign took place that the independent oversight made sure that the Commission's recommendations were adhered to. And while I was not able to be here this morning because the Judiciary Committee was marking up the immigration bill, the report that I got of this morning's hearing was that you all were less than precise in terms of saying which part of the Commission's recommendations you would adhere to. And I'm just very concerned that at least this part of the Commission's recommendations be adhered to and that somebody from the outside look at the redesign of that solid booster rocket motor so that we won't have another cozy arrangement that apparently led to the disaster.

Dr. FLETCHER. That particular recommendation—there's no question about it. We accept it and we are implementing it.

Mr. SENSENBRENNER. OK. Thank you very much.

I'll yield to the gentleman from New York, if he wishes to——

Mr. BOEHLERT. Yes.

Mr. Aldrich, you said you're reassessing to make certain that the design specs are valid. What I want to know is, who makes certain that the design specs are met? Is it the reliability and quality assurance people?

Mr. ALDRICH. I'm sorry, I meant to specifically indicate not only that the specs were valid, but also that the design of the hardware and the testing and analysis of that hardware assures compliance in an engineering sense. That's done by the full engineering elements available to each of the projects, both NASA and Government, not only the R&QA organizations in each organization, but also their primary design engineer organization and their project management as well.

Mr. BOEHLERT. Fine. Thank you.

Mr. ROE. The Chair recognizes the gentlelady from Tennessee, Mrs. Lloyd.

Mrs. LLOYD. Thank you very much, Mr. Chairman.

Dr. Fletcher, it certainly is a privilege to meet you, to be able to welcome you back. I feel like I'm a real oldtimer that we're here together after all these years; and also to see your colleagues here with you. We appreciate your time and the attention that you're giving this matter.

I'm really playing hopscotch back and forth. I'm attending hearings across the hall on some of the problems that the TVA has. In this hearing we're trying to assess the tragedy and across the hall we're trying to prevent a tragedy. But in the two hearings it seems to me that there are so many parallels, that there are so many matters that were not brought to the top managerial level. There was a lack of communication. There was a lack of focus on really design perfection.

And one of the statements that really brought home to me in one of the—in testimony from across the hall—"Management's overriding concern for cost and schedule has led to the faulty design and construction of TVA's nuclear power plants."

Well, this is bad, but to me what is even worse is that I really think that safety in itself is superficial. I think that we're talking about something that's so much broader than safety. I think that safety is something that happens. I think what we're talking about is quality workmanship and management, and a level or performance in this agency.

Now it seemed to me that the NASA of the seventies was really known for its excellence and that this high degree of safety was something—it was part of the picture. It was something that happened, whether the agency is designing or engineering manned or unmanned systems. And wouldn't you agree that if we put the proper picture in, if we put the proper perspective in and demand the quality and excellence, that safety will be the byproduct?

Dr. FLETCHER. Well, I think that safety, of course, is the primary concern, but the things that you mentioned, Mrs. Lloyd, are absolutely essential to safety. You've got to not only have high quality and high reliability on all the parts, but you've got to have confident judgment on all these things with people involved, and there has to be good communications, as was mentioned earlier, between the people. So if there is a question about some item, everyone is free to raise the question with his associate or compatriot and resolve the issue. That's all part of what we mean by safety. But certainly reliability and quality of design is an essential part of safety, yes.

Mrs. LLOYD. It seems to me there is a blatant disregard for communication between your levels. But another thing that really disturbs me is the distinction that we've heard yesterday and today between technical people and the management people.

Now what really happened—I don't really to delay this, Dr. Fletcher, but what happened to the technical manager in aerospace that made these decisions? We had people that had the sufficient data to act upon. We had people like George Lowe and Werner VonBraun, Abe Silverstein. Why don't we have people like that today that are technical managers?

Dr. FLETCHER. Mrs. Lloyd, it's interesting that you should raise those names. Of course, Werner VonBraun is gone and George Low is gone, but we did have Gen. Sam Phillips and Dr. Eberhart Reiss and Brainerd Holmes and Abe Silverstein, some of the old-time veterans, we call them—they didn't like to be called "old-timers"——

Mrs. LLOYD. They were technical managers.

Dr. FLETCHER [continuing]. In about 2 weeks ago and had an interchange with the current people. And I think that the main difference, if I might summarize what we came up with, is that there was a collegiality in that group which has to be redeveloped among our own people and is in the process of being so. They had no questions about the competence of our people. Those, of course, were giants because they were the people who put us on the moon and brought our astronauts back safely, but we have giants, potential giants, in NASA now. We have to make them work together properly as a team.

Mrs. LLOYD. I referred to NASA as a wounded eagle yesterday. I really think that if we are going to fly again we're going to have to make the demand for excellence and the quest for excellence uppermost in the NASA program, and we want to be a part of that, that we will not settle for less.

And this committee and the oversight functions as well as, I'm sure, you and Admiral Truly and Captain Crippen share my goals.

Yesterday we also learned that hindsight is a lot easier than oversight, but I would like to review the comparison between the Apollo 204 fire and the accident. It seems to me that the flaws are so much broader now than they were 20 years ago and that certainly our resources are more limited than they were 20 years ago.

And it seems like that we're going to have to make some policy issues where we're going to go in our program, such as we decided to go ahead with the Apollo program. Where do you think that we are going? What is—what do you think is going to be our main goal?

Dr. FLETCHER. Well, Mrs. Lloyd, that's a broad question, but let me give you some broad——

Mrs. LLOYD. I realize it is.

Dr. FLETCHER [continuing]. Answers——

Mrs. LLOYD. It allows for your perspective.

Dr. FLETCHER [continuing]. The best I can.

Our first and foremost goal is to return the space shuttle to safe flight as soon as we feel it is safe to fly. We we will carry the missions that have been assigned to us to carry. Admiral Truly and his colleagues are going over the proposed manifest very carefully.

Following that, then we plan to launch the payloads that we talked so much to you about over the years, the crucial scientific payloads—for example, the Hubble Space Telescope and the various Centaur missions: Galileo, Ulysses, Magellan, and so forth, and the Spacelab. So following return to flight, we'll pursue those programs.

The little longer term goal—you also are aware of—is to get to the space station. We need to have an adequate transportation system, both to carry men and equipment back and forth to that space station, and also to assemble the space station. So we have to have a reliable space transportation system to do that.

Beyond that, we make studies. We have no commitments. We have some guidelines that have come to us from the Tom Paine Commission. He proposes several alternatives—an advanced transportation system to replace the shuttle, for example, is one. A national aerospace plane is another possible direction to go, which is already in the process of being implemented.

And, finally, we can't forget that our long-range mission is to move out into space with men and women and equipment and do useful things, and that includes the Moon and Mars and places like that. That may have to wait until the turn of the century, or at least until there is a change in the budgetary environment.

Mrs. LLOYD. Thank you very much.

Thank you, Mr. Chairman.

Mr. ROE. I thank the gentlelady.

The gentleman from California, Mr. Packard?

Mr. PACKARD. Thank you, Mr. Chairman.

Welcome back to NASA, Dr. Fletcher, the fiery furnance at the present time anyway.

I'd like to follow the same common thread of questioning this afternoon. I'm still not satisfied that we have all of the commitments that I would be looking for.

The Commission found that the joint testing and the certification process was inadequate. What is your understanding of what the Commission means by those inadequacies?

Dr. FLETCHER. Well, I would have to refer to Admiral Truly and his colleagues, if you don't mind, Mr. Packard.

Mr. PACKARD. Please.

Admiral TRULY. Let me give you my view, and I would suggest that that would be a good question tomorrow for the head of the accident team.

I think what the Commission was saying is that, if we had had prior to the first flight of the shuttle the experience of the—about a thousand tests that we have done since January 28 on the joint performance of the solid rocket motor, we would have not have flown that design. We'd know far more about it, and we can credit that to hindsight if we want to, but the commission concluded, and so did the task force, and so did I think the technical people, both at Thiokol and Marshall, that we did not understand the performance of that joint. I think that's what the commission meant.

Mr. PACKARD. And I do not wish to dwell on hindsight, either, but I certainly want to profit in where we go from here in developing that process so that there are not those inadequacies in our redesign of this joint plus the looking at other inadequacies in the system that have already been identified.

I think what distresses me and disturbs me the most is that we do not have in these areas, some of which are very critical areas—we have ongoing rethinking and redesigning of those areas, but we do not have a good flow of those redesign factors into the system, the launching system.

A good illustration is the brakes, which we know that there are flaws there. We've had problems. It's almost like the joints. They have manifested themselves in mission after mission, and yet we have not moved in to a new design to correct that problem. And I'm not suggesting that we stop all flights until we correct that problem. Sometimes—it certainly would have been beneficial to have done that with this—with the joints. But that's not, I suppose, what we would expect.

But there ought to be a time when the new design is moved into the system over a period of a long-term picture without having to delay flights. And yet we still see that we have brake problems, we have tire problems, we have steering problems, we have main engine motor problems or main motor problems. And I'm not persuaded that we are making the kind of progress on these other weak areas to the point where we won't end up with another accident caused not by an improved design on the joint, but on a weakness in the main motor or some other problem.

I was at the landing where those three tires blew, and that was alarming. And I think it is critical and could cost life and equipment.

I guess my question is, are we going to see the redesign of these other areas that we know are weak moved into the system without delay and at the same time without rescheduling the launches?

Dr. FLETCHER. Well, Mr. Packard, Admiral Truly and his colleagues can give you a better answer, but let me just say very quickly that, since we are down because of the seals in the solid rocket booster, we are taking a look at all of those items, particularly the ones you mentioned, but a longer list of items.

Mr. PACKARD. And some may come up with Mr. Aldridge's point that he made——

Dr. FLETCHER. They may very well.

Mr. PACKARD [continuing]. To review all of your specs.

Dr. FLETCHER. And so I think that at least is being addressed. The first part of your question—suppose there are new things that come up during future flights; isn't there a way to phase those new redesigns into the space shuttle transportation system, so that we can fix it as we go along? And I think that will be part of our plan in the future.

I don't want to speak for Admiral Truly, but that's my opinion.

Admiral TRULY. Well, I was going to request the opportunity—as an example, on the brakes, to ask Mr. Aldrich to say a word, because I view the brake problem as an entirely different sort of a thing than what caused this accident.

It is true that we have had brake problems over the years. As I matter of fact, I flew the second flight of the *Enterprise* on approach and landing test in 1977, and that was the first indication—it was the second flight of the shuttle and it was the first indication of a problem with brakes.

However, from the time that that happened until today, the program has worked the brakes very hard. We have moved out and had planned to move out prior to this accident on a redesigned brake that will be accomplished during this period. And we need to do that.

But there is a big difference in working difficult, complicated, and contentious technical problems on top of the table, and having a problem where a breakdown in communications doesn't elevate the severity of it so that we do work as a system. We will never make spaceflight totally risk free.

Mr. PACKARD. I know.

Admiral TRULY. It can't be done or we just ought to quit and not try.

But those other concerns in the Commission's report—and in no way do I want to say that I don't go along with those concerns, because I do, but those are concerns that have been worked in a different manner, I think, than this solid rocket motor joint. And, to me, that's a big difference.

Mr. PACKARD. One very quick question, if I may, Mr. Chairman, that I hope will just require a short answer.

At no place in your report or in our discussion have you indicated that you would report and brief this committee or parts of this committee on redesign submissions and considerations of the joint. I presume that we would become a very important part of that review before there was any money, although obviously we would not allocate funds for those redesigns until we were satisfied that they would meet the requirements.

True, the National Research Council and a variety of other in-house organizations will look at them. I've not seen any commitment that they would come back to us before they were approved.

Dr. FLETCHER. Mr. Packard, that is our intention—to bring before this committee design changes, improvements, gradual steps toward the eventual reflight as we go along.

Mr. ROE. If the gentleman would yield?

Mr. PACKARD. Yes.

Mr. ROE. I assure the gentleman from California, as long as the gentleman from New Jersey is in the Congress of the United States, along with the other people on this committee, there will be no flights around here until this committee is satisfied that the requirements are met, and I think that that's what Dr. Fletcher is saying. And I think that point ought to be made abundantly clear, because—if the gentleman would yield—the point has been out, "Well, shall Congress take a closer oversight," and I think that's—as you are doing things in NASA to revamp NASA, that's already been decided. So the answer, sir, is not only the funding; it's the action of this committee through oversight and then through allocation of authorizations.

If the gentleman would yield further—I want to back up a little bit on Mr. Packard's comment on the landing gear and the tires and the other areas. Now I hope—and I think that's the point you were developing—I hope that when we spoke of critical—let me ask a question, if the gentleman will forgive me: Is the problem of the landing gear a critical item? Is that in any one of—is that critical 1 or 1R?

Mr. ALDRICH. Yes, it is. Yes, it's criticality 1.

Mr. ROE. It's criticality 1. Now, to me, criticality means that, "Hey, guys, that's as bad as anything else on that criticality 1." Is that a reasonable point? We don't have any diversification. We say that if it's critical 1, to me that's critical 1; it's go or no go. Is that—am I wrong in understanding your nomenclature?

Mr. ALDRICH. It's criticality 1 in that failure can be catastrophic.

Mr. ROE. That's the point I'm making.

Mr. ALDRICH. However, design margins can be enhanced tremendously, and that's what we're attempting to do with the brake redesign.

Mr. ROE. Yes, but that's not the point I'm making, and I think it's terribly important because I want our hearings to have been thorough and not spongy, and there's nothing personal in what I say. I'm not as articulate as some other people in getting their point across.

But it seems to me basically when the Commission spoke to the critical areas, they said "must." Now to me that means—you know, that can be translated into legislation, too. I'm sure you're aware of that.

If it's a critical item and you take X items and you put it on the No. 1 list, now the No. 1 list, as you say, that could be a list—anything that would happen on that particular part or piece could be critical to the extent of causing a severe accident or even death. Is that what critical 1 is about?

Mr. ALDRICH. Yes.

Mr. ROE. Well, now, how can we, then, take the point of view that, as important as the O-ring is, which is the heart of this particular process that we're going through now, certainly the landing gear is critical, and anything else that's critical, what is also critical—would we say that, and I'm thinking down the line in this direction—we have three orbiters that we have to retrofit. And any decision that's made ultimately by Dr. Fletcher's folks and your people, if you're going to take a critical item 1 on that has to be redone, it means it's got to be redone on all the orbiters; isn't that correct? Wouldn't you'd say that would be correct?

Mr. ALDRICH. Yes, the design——

Mr. ROE. Basically. Otherwise, what do we—we're not going to fix up one and let the other three sit there and do nothing. I mean, you know, we don't want to get too testy today, but we're talking about taking parts from here, there, and whatever. If we're going to provide you with the tools to do the job, Congress is equally as important and responsible to provide the resources which we expect NASA to come back and tell us and say, "If you want the totally safe system, this is what it's going to cost you." Now if Congress wants to play the games and not provide the funding, then they are not doing their job to the American people, either. It's not up to NASA to tell Congress what they should or should not be doing. It's up to us to understand from you—if I were king, what would I do as the best thing in the country? That's what's before us today. That's what we're trying to decide.

We want to be able to go back to the full Congress and say:

> If you're really serious about being in space, and we've crystallized the safety issue, which we've done, we're coming back and saying, "We need these assurances. We need this testing. This is what we need."

Now it's up to us from a management point to determine what you need and how you're going to do it. You tell us that.

Now I go back to the criticality issue. If we're going to fly anything, it would seem to me that the critical items are first and foremost in this committee's mind. And anything that would not meet those needs, the O-rings notwithstanding, we consider that to be important, including those landing gears.

Now does somebody want to respond?

Pardon my enthusiasm, but I get enthusiastic.

Dr. FLETCHER. Admiral Truly, having flown the orbiter, ought to respond at least about the brakes.

Mr. ROE. I would hope so.

Admiral TRULY. Well, I want to tell you that what you just said, I'm a thousand percent in agreement with.

Mr. ROE. All right, then, we'll vote. [Laughter.]

Admiral TRULY. That's what this review that Mr. Aldrich is heading up is precisely doing, and that is looking at those items, relooking at the design. If they require fixing, we're going to fix them before we fly.

However, there may be a case where we could put restrictions on the flights and fly three flights under restrictions because of the leadtime and do it. So there's a lot of things in that——

Mr. ROE. We flew 24 flights. I don't want to beat this horse to death, but what I'm trying to get across—we said that as far as NASA—and the eloquent presentation Dr. Fletcher made in the beginning I just loved because he said let's get on with it. But it seems to me that if we're going to get the answers back from you folks now and we're going to get the answers tomorrow from the technical, all we'll know is the facts.

We're coming back and we're saying, "Yes, sir, those things have to be repaired. We're not going to gamble anybody at this point until they are repaired."

And Congress ought to be able to say to NASA in response, "If we're going to need these funds and these kinds of resources to be able to the best we know how in America as far as safety is concerned, that's No. 1."

Now we don't want to talk about necessarily redundancy in every part. That's not practicable. We understand that. But we are coming back and saying, "Yes, we could fly if the temperature was a little here and we didn't have that ice"—and I don't want to—the answer is no. We're coming back and saying that everything that's on that critical list to us is critical, and everything that's on it—that's why I want to be able to say when we finish our work.

Admiral TRULY. Yes, sir; and I agree with you.

Mr. ROE. OK.

Mr. VOLKMER. Would the gentleman yield? Would the gentleman yield for just a moment on the brake question?

Mr. PACKARD. Before I yield, let me make a comment on what the chairman has just said, and that was the whole point of my question. We had 9 years of forewarning on the joint, that it was a flawed joint. There should have been redesign going on during that period of time and a phasing in so that, as long as we stayed within the parameters that made even a flawed joint fly safely for 24 missions, that was acceptable. But we should have corrected that joint long before the 9 years was up.

I'm saying the brakes, the main motors, and other critical areas that we already know have got some flaws in the design and need to be corrected, we ought to be on about doing that and phasing it in and not wait for an accident to force it to phase it in.

Mr. VOLKMER. Would the gentleman yield?

Mr. PACKARD. Now I'll be happy to yield.

Mr. VOLKMER. Yes; and along that line of redesign, I'd like to know if the redesign includes eliminating it from the criticality list for abort missions where you have an abort, which is a lot different in that you've unloaded the payload bay.

Admiral TRULY. Are you speaking again about the brakes or the landing gear?

Mr. VOLKMER. Yes; and, of course, the——

Admiral TRULY. Yes. Criticality 1 items are items that must not fail because they would cause the loss of vehicle or crew.

In the case of the brakes incidentally, Mr. Aldrich has approved the new brake design and money, and I have approved it at level I, and it is being turned on, and we're going to do it.

That will not take, however, the brakes out of being a criticality 1 or 1R item. They are still that critical, and they are that critical for aborts or end-of-mission landings, whenever we would land the shuttle.

Mr. PACKARD. Thank you, Mr. Chairman. I have no further questions.

Mr. ROE. Just to clarify that point, I think we understand exactly what you're saying. You're saying, "Look, we're going to be able to present the best we know how, but it still stays on criticality 1 because if anything happened to it, we'd still have a problem."

But if we know something's wrong—do you understand where I'm coming from?

All right, the gentleman from Texas, Mr. Andrews.

Mr. ANDREWS. Thank you, Mr. Chairman.

I would like to go back to Mr. Mineta's line of questioning. I think the issue of the decision to launch or not to launch is so fundamental to these hearings and certainly to the Commission's findings. I'd like to know Dr. Fletcher if you concur with the view that I believe the Commission is saying that the information flows downhill pretty easily, but coming back in the other direction there has been some serious problems with breakdown in communication. Is that a fair assessment of the situation?

Dr. FLETCHER. Mr. Andrews, of course, I've only been here a short time, but I accept the committee's views on that. They have worked with our own people, and they've worked long and hard, so I have to accept the fact that their conclusion is correct.

Mr. ANDREWS. What do you think the largest problem is?

Dr. FLETCHER. I think there's a large number of problems, Mr. Andrews, all of which have to be looked at.

Mr. ANDREWS. What are those problems.

Dr. FLETCHER. It has to do with the procedures. It has to do with the definition of the procedures that are written down so that people can follow them. When they're not followed, we have to have a way to check on any deviation from those procedures. But that's not the only thing. You have to have two-way communications, as we mentioned before. You have to be able to interrogate people all the way up and down the line from level IV.

Mr. ANDREWS. What has been the most serious problem with that?

Dr. FLETCHER. In the past? I really can't comment. I've been gone for 9 years. I think somebody else that was involved in the investigation would have to answer that. But that in the future is the thing that we're talking about, when we say tighten up procedures and communications.

Mr. ROE. Will the gentleman from Texas yield for a moment?

Mr. ANDREWS. Yes.

Mr. ROE. I think what we, in our enthusiasm today, and I'm probably the most guilty one of the whole group that are here, that we have to recognize that the leadership that's visiting with us today and testifying are all relatively new. They've had, you know, years and years of experience, but they're back into the stream now.

And I think that part of what the Commission is saying to us that these are the group—the broad-based areas where these major problems are resolved, and then are looking down the road for this new team to resolve them. And it would seem to me that—if the gentleman would yield further—that I would hope that from our committee's point of view, that after we finish with this particular phase we're going through and you get back to work, then we will call you in from time to time to bring us up to date as to exactly what management improvements are being made, what exact technical improvements are being made, and so forth and so on, for what that's worth for the gentleman's line of questioning.

Mr. ANDREWS. Well, then, let me ask that question to Dr. Graham.

Dr. Graham, what do you think the most serious flaw has been in the decisionmaking process to launch or not to launch?

Dr. GRAHAM. I have more time at NASA during this tour than Dr. Fletcher because he has weeks and I have months, but I wouldn't represent that as comprehensive. Nevertheless, in my experience there I believe that there has been a serious problem in the information flow upward, as you identify, and I believe that goes up to the top of NASA, to the Administrator's office itself, and certainly to level I and I believe to level II as well.

That's to some extent an issue of the entire internal environment in NASA and the way it functions, the way information is received at the upper levels of the organization, the way it's understood, and the feedback that's provided.

I have tried to establish a policy of not shooting the messenger when information comes up, even though the information may not be information that goes in the direction that you would like the program to take, but rather to try to change the program and give the appropriate guidance and feedback to the system, but to encourage the flow of information.

I believe that has to be done over a substantial period of time and at a number of levels for information to come up through the system. As you know, that's caused some problems as well. In fact, I had to change the internal organization to remove one person out of the information flow line to make sure it came to me more quickly after the accident.

I think that and other things are beginning—we're beginning to set a tone inside NASA to encourage information flow, and I believe Dr. Fletcher's extremely receptive to information of all sorts coming up through the system. That, I think, is an absolute mandate on the Administrator's office in order to have the information flow to run a system such as the shuttle.

Mr. ANDREWS. Captain Crippen, would you comment on that? What, in particular—it appears obvious that the astronauts have not had adequate input themselves into the decision to launch or not to launch, and what specific steps do you think need to be undertaken right away by NASA to change that?

Captain CRIPPEN. Mr. Andrews, if I may comment on the initial problem—of course, what the Commission was addressing was the fact that the information regarding all of the failures within the O-ring itself had not flowed forward over the years adequately such that it was emphasized as to its criticality, and then when we got down to the actual launch and we had temperatures that were low and certain engineers were concerned about that, that information did not flow up.

I do not think that that means that the whole system was not flowing information properly. I think it does point out a specific flaw, and we probably had others, but it does say that we have to go back and reexamine our information flow.

People have emphasized that the astronauts did not know. Just telling the astronauts is not going to solve the problem, although if somebody came and whispered in our ear we had a problem there, we would have probably brought it forward. But the proper way to bring it forward is through our program managers, and that is the way the astronaut office normally performed, and I believe that's the proper case.

For the tasks that Admiral Truly has assigned to me, I am going to try to propose an organization that does give us information flow, smooth information flow both up and down. I think we said that the information flow down is good. Maybe information down was not communicating properly to the people down in the trenches that, yes, we were interested in flying at an accelerated rate, but we were still interested in doing it safely. Maybe that information wasn't conveyed properly.

Anyway, those are the kinds of things. Up and down flow has to be smooth and has to be simplistic to do that. That also follows over directly to the launch decision process. The closer you get to a flight, the faster it has to flow, and it has to flow very smoothly and people have to know who can call the signals, and those are the kinds of things that we're going to be working on over the next few weeks to try to see if we can come up with a proposal that will at least make that work better.

Mr. ANDREWS. Thank you.

Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman

The gentleman from Michigan, Mr. Henry.

Mr. HENRY. Thank you, Mr. Chairman.

I regret I missed about 1 hour of the hearing early this afternoon, but an unanswered or unasked question continues to trouble me, so I'll ask it even though it's simple and basic. And I'll begin, I think, with Admiral Truly, if I may.

In your opening statement you suggested—you said that you were in general agreement with the findings and recommendations of the Rogers Commission report. Do I take it that that leaves you some leeway to suggest you're not in complete agreement or——

Admiral TRULY. No. I want to make it clear that there are some choices that the Commission left us, very appropriately. And, as a matter of fact, even though I did not see a single one of the specific recommendations until the report was published and was not privy to them, I discussed them many times with commission members and with Chairman Rogers, including, incidentally, the oversight of our SRM redesign. I think that is very appropriate, and I'm glad he recommended it.

I don't know of a single recommendation in here that I am not in agreement with. However, there are some choices in it. For example, the choice of where in the organization the person that runs safety, reliablity, and quality assurance is a choice that the Administrator will have to consider and make.

The choice in the redesign of horizontal versus vertical testing the Commission, you notice, did not direct us to test vertically. They directed us to assure that we looked at it and made a reasonable decision. I forget exactly what the words are, and we're already quite a ways along that track to do so.

But I am in agreement with his approach. As far as I'm concerned, this is a great roadmap to get started with, and I'm very happy with it.

Mr. ROE. Will the gentleman yield?

Mr. HENRY. Yes.

Mr. ROE. I think we also ought to get on the record that through Dr. Fletcher and yourself and Dr. Graham that there's a host of other things that are emanating from NASA itself in its own program. It's not just this group you're looking at. There's all other things that the new management group is looking at. Is that a fair comment to make?

Dr. FLETCHER. Yes, Mr. Chairman, that's what I tried to indicate in my opening remarks. Having said that, though, I think I want to reiterate what Admiral Truly said; namely, that we're taking this Commission report very seriously as an important part of what we're doing to fix the shuttle.

Mr. HENRY. At this point, if I may, Mr. Chairman—we're all taking it seriously. I just want to have on the record that the agreement is complete, not equivocal, acknowledging obviously that in a number of areas, particularly technical areas, discretion was given to you.

The reason I raised the question was because you chose the word "general agreement" in your written testimony but also when Mr. Aldrich was responding to one of the earlier questions, I think by Mr. Scheuer or Mr. Nelson, relative to the safety appeals outside safety process, he suggested, "Well, I'm in general agreement but not in particular agreement."

And what I would like to have as clearly as possible to those areas in which complete agreement doesn't mean unequivocal agreement some guidelines. I mean that clearly to me as a layman—this report is going to be my handle in trying to follow what you're doing, what else you're doing.

May I follow with another question? I'm concerned that we deal with the recommendations that at some point the agency makes available to the members of the committee some establishment of written, objective criteria by which it believes it will, once having implemented it, satisfy the recommendation.

I'm concerned a little bit about getting caught in a little bit of a mish-mash. This is particularly because most of us here are not engineers and technically qualified and yet we bear responsibility to oversee.

For example, when we had the earlier testimony by Mr. Aldrich that each subsystem was devised and certified to be 31 degrees Fahrenheit workable on the low end temperaturewise, and yet to find out that the subcomponent parts were not so certified, I don't know how you have a subsystem without the parts meeting that criteria. That obviously was one of the issues here.

Can we get some assurance that you're going to give us some working definition along the way as to what you mean by measurable, objective criteria, whether it be the brakes, the O-seal problem, what have you, so we have something when we go back and we talk to commercial engineers or other engineers and say, "Does that do the job?"

Dr. FLETCHER. You mentioned several things, but let me comment on one of them. As far as taking the report seriously, as you know, we are obliged to respond to that report in a number of months. That will be a written response and done in some depth.

We are trying to give you a general feeling about our reactions to the response, which are positive. We think the recommendations are right on target, something that I would have done had I been as smart as that Commission. And so that part I think we can assure you that you will get a very definitive response.

With regard to the other issues that we ourselves are looking at in the criterion for what is safe and what is not safe—guidelines, as you call them—I think you're entitled to have a feel for that but we haven't yet developed them. After all, we just started the response.

Mr. HENRY. Thank you.

Mr. ROE. Don, you are up next. Do you want to wait until we return from this vote? This is the second call.

Chairman Fuqua, I say you're up next, but would you rather wait——

Mr. FUQUA. I'm trying to find out what type of quorum call we have.

Mr. ROE. It's a vote. It's the last part of the second call.

The committee will recess for 10 minutes while we go vote. Bear with us.

[Recess taken.]

Mr. ROE. The committee will come to order.

And when we broke up for the vote the last time, we were about to defer to our distinguished chairman, the Honorable Don Fuqua from Florida.

Mr. FUQUA. Thank you, Mr. Chairman.

And I know that Dr. Fletcher and all his associates, that this has been a long day and probably they need to spend some time back trying to solve some of the problems.

I was going to ask of Admiral Truly—in the previous colloquy with one of the members—I think maybe it was Packard or maybe Volkmer—a subject came up of brakes and the criticality of brakes, and that is—that that could be a critical 1 on an airplane or an automobile. I know many times when I've landed at National Airport, particularly under adverse weather conditions, I was very glad that the brakes worked because otherwise I'd go into the Potomac River on one end of the runway or the other, depending on which way you were landing.

But would not you classify that as a critical 1 item?

Admiral TRULY. That's right. I think that's a good way to understand criticality 1 and 1-R, as a matter of fact, as just an automobile. Your right front wheel is a criticality 1 item. It falls off; you have the chance of losing your vehicle and you. If you have a problem with it and redesign it, recertify it, it's still a criticality 1 item.

Your brakes, depending on your car model, may be criticality 1R. You may have a disc brake system that has a separate front brake system and rear brake system, and you would have to lose both of those to get in the same situation. But to me that's a good way to understand it, but, nevertheless, even after you certify it properly, your right front wheel still is criticality 1, no matter how long you drive your car.

Mr. FUQUA. I was going to point out to Dr. Fletcher—reference was made earlier about where are the giants in NASA. Do we have the giants as we had in the past?

I remember sitting in this room in 1967 when we were investigating why pure oxygen was designed to go into the Apollo capsule, and that's fine as long as you have no electrical fire or any sparks. We found that out in a very tragic manner. NASA found that out, and some of those giants of NASA found that out that participated in that. And I don't mean in any way to besmirch their record; it's a fine record. I think we have some very excellent people in NASA today. Many of them are sitting right at that table. Many of them are in this room or have been here or will be here tomorrow, and are scattered throughout the whole NASA system.

Sometimes success breeds complacency. I think that might be what happened in this particular case. But it's unfortunate we had to find out the way we did, but I think we do have some very bright and talented people in the NASA organization and in the industrial team. And I hope that we never lose sight of that fact—that they made some great contributions over the years, and I don't think it means we have an erosion of talent in this country.

I remember the early days, too, when Mark Russell, the political humorist here in Washington, referred to the Vanguard as a civil service. He said you couldn't fire it and couldn't get it to work. [Laughter.]

That was his remarks, not mine. But the—so we had our lumps in the early days of the program. It's still a very difficult thing to do.

But I would just like to set the record that there are some very talented and bright people in NASA and in the industrial team that can contribute, and have contributed, and will contribute to our Space Program—not only the shuttle where we are today, but also the space station and the many other scientific—the feat earlier this year of the Voyager spacecraft was certainly a great credit to a lot of very fine people. It's not very easy to transmit or get a vehicle to go as far as that vehicle has, and the project of Galileo and some of the others that are—and the Hubble telescope which had its problems along the way.

But I think we ought to also sometimes look at the good side, and I think the Commission did in their closing comment that we should move forward with the program. There are a lot of fine and talented people and a great organization, and I—while we've had a bump in the road, I certainly hope that people within NASA do not become discouraged and think that Congress or the American public is down on them as being incompetents and people who are not capable of the task. They are capable of the task, and I'm sure that they'll prove that, given an opportunity.

Thank you.

Mr. ROE. I thank the gentleman.

We now recognize the distinguished gentleman from Utah, Mr. Monson.

Mr. MONSON. Thank you, Mr. Chairman.

Dr. Fletcher, being from Utah and knowing that you've been absent for a long time, we still consider you one of us, and we are proud of the work that you have done and commend you for the public service that you're showing at this time and the spirit of that public service that you're showing, and wish you all the best as you go about these responsibilities.

I have developed a concern throughout this process over whether or not we're doing enough to determine and gather enough data prior to launch as to whether or not weather conditions are suitable and such. Do you—have you gone far enough in the process yet to know whether or not it would be necessary to check more areas of temperature, more—whatever can be done to determine the effects of wind at higher altitudes and such? And I know that technology is not fully developed in that area yet, but what do you anticipate happening in that regard, if anything, at this point in time?

Dr. FLETCHER. Mr. Monson, that's an awfully good question. The only reason I'm responding instead of Admiral Truly—we had a very detailed discussion about that with Captain Crippen yesterday. That's one of the difficult things to do because you have to predict weather not only at the one site before taking off, but you have to be able to predict the weather at the alternate landing sites in case of an abort.

We have improved some over the years our weather prediction generally, but local weather predictions are still very difficult, not quite a science, and we're in the process of looking at better ways of making those forecasts.

Having said that, it may be that Captain Crippen or Admiral Truly would indicate what progress we have made.

Admiral TRULY. I don't have much more to add to that other than the fact that we recognize very clearly that we need better technology, frankly, in the country for weather forecasting and, very specifically, in the space shuttle program, we need the best technology that we can get at the Cape. Precisely where that has gone I am not familiar with, but we are going to sure pursue it and make sure that we have the technology to do the best we can and, then, the mission rules and the discipline to make sure we obey our rules when we get back to flight.

Mr. MONSON. I am not only concerned about forecasting; I am concerned about actual conditions and our ability to measure them. It is one thing to know the temperature 1,000 feet from the vehicle but right up at the vehicle itself, are we going to be doing more in that regard? Are we going to know more about the effects on the different parts of the vehicle and such in advance of what we have done in the past?

Admiral TRULY. I am sure that we will but, again, we just aren't far enough in the design process. I would comment that even though the cold weather that morning was not found to be the cause of the accident, it certainly was a possible contributing factor in the failure of the joint. It has made the entire system very aware of environmental effects.

On the joint redesign, itself one of the requirements that the redesign team will very likely choose is that even if could withstand cold temperatures, it probably will be environmentally controlled with heaters. If that is the case, we may very well have direct instrumentation on the pad, but that is a detail best left to the redesign and certification group.

Mr. MONSON. With regard to redesign, you expressed a short time ago that there was a lot about the joint we didn't understand even in the early launches. I understand that effects of rotation and such caused the parts in that joint to respond differently than it was anticipated they would when they were originally designed.

What can we do to make sure that we understand enough before we have gone through the process of several launches before we gain the knowledge that we need to to understand exactly how these parts are working and whether or not they are working the way we thought they would when we designed them?

Admiral TRULY. Well, I don't have a pat answer, but I can tell you that I am a great believer in ground testing and understanding the systems through test and then operating systems more toward the middle of the envelope. We have done that in the main engine program in the past years. I haven't had the opportunity to take a look at that program, but, in general, I would say that I am an advocate of spending money to do testing of critical parts on the ground. We may very well find in the program that we make recommendations to have a more robust test program, particularly on criticality 1 items.

Mr. MONSON. Thank you, Mr. Chairman.

Captain CRIPPEN. Could I add just a little bit to that, that the main reason that we are smarter about the way the joint performs now was not just the accident. That told us we had a problem. But we have done a number of subsystem tests that have made us smart about the way the actual joint operates.

John Thomas from Marshall who was the man that, although he was a deputy, actually did the lead on the accident analysis was the prime driver behind most of those tests. He is now the lead on the redesign effort. Consequently, I am certain that he is going to use that same fundamental rule in the design of the new joint.

Mr. MONSON. May I follow up, Mr. Chairman?

Mr. ROE. Yes, of course.

Mr. MONSON. It causes me concern, though, when I hear that what we originally anticipated would happen may have been exactly opposite of what actually happened when the rocket was fired in certain parts of that, especially surrounding the joint in this instance, not this particular launch, but the performance of the joint overall. I guess you can never be 100 percent sure that you have all knowledge, but I assume that from your statements, those tests will include making sure that what we thought we were designing is actually the way it performs.

Admiral TRULY. Well, if I understand your comment properly, personally, I am going to gain the confidence to go fly again not from the design but from the testing, the certification and the test program. That is why choices like the manner in which we test, the configuration in which we test, the analysis of the test data, that is the real data. We want to go fly again and the Nation desperately needs us to get back in the air, but the proof of the pudding is in the test program, and, as a matter of fact, no matter whether it is July 1987 or any other date, it is primarily the scheduling of that test program with enough time for the system to analyze it that will give us the confidence.

And when we get started flying again, we are going to have enough time in between the flights so that we can take the motors apart, analyze them at the factory, and before we commit to the next flight make sure that we have no evidence of a problem in the joints.

So, in general, the confidence that we all gain in this redesign will be through the test programs. It is a very important part of it.

Mr. MONSON. Thank you.

Mr. ROE. The Chair recognizes the distinguished gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Not in the report but attested to by several Commissioners since the report has come out is the fact that some of them claim that if the accident had not happened, the system would be shut down by now anyhow because of a lack of spare parts and a lack of resources. Do you agree with that?

Dr. FLETCHER. Mr. Walker, I am not sure you are addressing the question to me.

Mr. WALKER. Whoever might know.

Dr. FLETCHER. I have read the same statement. I think, however, there has been a rather thorough look at that by Admiral Truly and his associates, but I don't know which one is best qualified to answer it.

Admiral TRULY. Well, in a word, I don't agree with that, but I would rather Arnie speak to it, Mr. Aldrich.

Mr. ALDRICH. Two of the areas along that line that are brought out in the Commission's report deal with the availability of the flight software for the flights in 1986 and time for adequate crew training and the spare parts question. In leading into the flights for 1986 that were planned, we knew that we had a very, very tight schedule. We had packed into it all that we thought we could achieve, and we realized there was some risk of meeting all the milestones.

One of those areas which we spent a lot of time on was, in fact, the mission preparation and flight software schedules. We knew they were tight. We had touched all the bases, however, and had a map that said we could get there. I will be the first to admit that we might have run into delays and, rather than be shut down, we would have been delayed.

I think the same situation is true with the spare parts. There are shortages in some areas but not in others. Depending on which parts were needed and exactly what the configuration of the orbiter situations were, we again could have been delayed for parts, but I really doubt that we would have been completely shut down.

Mr. WALKER. But you would have been pushed very, very hard to complete anywhere close to the schedule that you had manifested.

Mr. ALDRICH. I think we would have been pushed hard to complete the schedule we had manifested, but we might have been close. We had some very demanding things in 1986.

Mr. WALKER. Why didn't somebody admit that to the Congress, then, when we were looking at some of these problems in the upcoming year when you were before us?

Mr. ALDRICH. Well, I can't respond to what was reported to Congress because I was not here on that subject. I did go at lengths in the program in support of the spare parts budget, particularly for the orbiter which is where the question is, and we were able to achieve the budget we achieved through the process we went through.

Mr. WALKER. We kept being assured over and over and over again that these manifested schedules and so on not only could be met but you were confident that we were moving ahead and that we were not going to have problems. Now, we find out that there may indeed have been problems.

Here is where it fits in, then, it seems to me, the overall part of the Commission. We have heard testified about today and we heard at that time that safety is always No. 1, that throughout this that you were being pushed hard, that you weren't sure you could make the manifest, and yet safety was always No. 1.

You said it, we believed it, and you had a flight record to prove it. In large part, it seems to me that what transpired then was that having had that on the record, we then get the Presidential Commission report that talks about the silent safety program. They specifically talk about things which are very disturbing:

"Organizational structures at Kennedy and Marshall have placed safety reliability and quality assurance offices under the supervision of the very organizations and activities whose efforts are their's to check."

That is not a safety program.

"Problem reporting requirements are not concise and fail to get critical information to the proper levels of management."

That is not a safety program.

"Five weeks after the 51-L accident, the criticality of the solid rocket motor field joint was still not properly documented in the problem reporting system at Marshall."

That is an atrocity.

It seems to me it is not only a silent safety program, it is an invisible safety program at that point. In the problem reports—and you, Mr. Aldrich—it says in the report that your office and the entire Johnson safety reliability and quality assurance directorate were not even on the distribution list for the problem reports. That is not a safety program.

What are we going to do to correct that?

Dr. FLETCHER. I don't know who should start, but that is an important element of the investigation that we are going to look into, both NASA-wide and in the shuttle program. We do have a safety program that we have to respond specifically to those comments that you just made, but I think, more important, we have to make sure that the appropriate safety program is implemented in the future.

Mr. WALKER. But let me just follow up on that. That is a general systemic breakdown. I mean, the things I am citing here are particulars, and you may address the particulars, but what you have got is a systemic breakdown. When you have got those kinds of problems, when the top level management isn't even on the distribution list for the problem reports, that becomes then a program on paper but not in reality.

What I am asking is, what are we going to do to solve that problem?

Admiral TRULY. Mr. Walker, I think that long journeys start with a single step. We have a lot of things in work to solve those specific problems. Frankly, even though the Commission did characterize it as a silent safety program and I accept every single one of their findings, they just have to be addressed. As someone said earlier, you can't do it with paper. You know, people who have thousands of flying hours aren't alive because the papers said for them to preflight their airplanes. They are alive because they preflighted their airplanes.

We do have a number of problems, but I think that we also have a system that was spending a great deal of time on safety. But somehow, through organizational changes and lack of discipline in some places, it needs to be shored up. I don't know how to answer your question except to have the commitment to redo it during this down time where it needs redoing, revalidate it where we deem it to be OK, and get to work on it. And that is what we are pledged to do.

Mr. WALKER. Well, let me just suggest that it seems to me that in reading the report that we got to a place where you had said to yourselves over and over again safety was No. 1 with you. You said it to us, as I pointed out before, and you had a flight record to prove it. And you began to believe that everybody up and down the line was concerned with safety, as we would hope they would be.

But as a result of believing that everybody was concerned about it, there was no one who had it as their primary concern. Ultimately, that led to a breakdown in the system.

So, it seems to me the correction somewhere along the line has to be that there has to be a primary concern about safety at some point in the system all the time. Would you agree with that?

Dr. FLETCHER. Mr. Walker, you are absolutely right. There needs to be a central point, not only in NASA but in each of the centers, in which safety is the primary concern. As a matter of fact, that should be the case with each element of this decision process, for example, starting with level 1 down to level 4. We do have a central safety location in headquarters in the chief engineer's office.

Mr. WALKER. If I may, Mr. Chairman——

Dr. FLETCHER. The fact that it wasn't communicated properly down at one of the centers, if that was the case, was a glitch and shouldn't have happened.

Mr. WALKER. Well, Mr. Chairman, if I might just take a little more time, the headquarters person—that is Dr. Silveira's office—he has one person who spends one-quarter of his time on safety, reliability and quality assurance. And he has one other guy who spends 10 percent of his time on shuttle safety. Now, that is not really much of a commitment on the part of the agency.

Dr. FLETCHER. I am not familiar with those numbers. We have safety in the R&QA office.

Mr. WALKER. As I understand, they are in the report. Those figures are in the Presidential Commission report.

Dr. GRAHAM. Mr. Walker, I would like to check that against the current status. I believe the Commission may have been reporting on the status at the time of the accident which is very germaine to the accident and very appropriate for them to report on. Some changes have taken place there already. But as Dr. Fletcher and Admiral Truly said, more changes are anticipated and certainly contemplated in that area.

I believe you are exactly right that there is a systematic problem there. The safety function can too easily become mixed with other functions inside an organization. When that happens, the results can be very serious.

At this point, it is the task before us to make sure that there are safety channels which don't cross over the program channels in such a direct way that issues which are safety issues coming up through the system become unidentifiable with program issues which have to be worked in their own way and in their own framework.

Mr. WALKER. Or, when you are trying to meet a manifest schedule that you know you can't meet anyhow, become the things that get shunted aside because they do not fit with what you have got to get done on the schedule that you have set for yourself which is an impossible schedule.

Dr. GRAHAM. Yes. That is exactly what I mean by a programmatic issue. A programmatic issue is meeting cost, meeting the budget, meeting the schedule, and safety cannot be traded off against that. Risk management has to be a discipline of its own. And those have to come together very, very high in the organization and not be suppressed.

If the *Challenger* accident has reminded us of anything it is the importance of keeping these functions separate and distinct.

Mr. WALKER. And at least the program managers have to get problem reports, right?

Dr. GRAHAM. That, certainly, and many other things as well.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. ROE. The Chair recognizes the distinguished gentleman from Missouri, Mr. Volkmer.

Mr. VOLKMER. Thank you very much.

I would first like to ask Bob and Dick somewhere along the line in reading the things I have read in the last few days, there is an impression in my mind that there is some concern—assuming that we didn't have the disaster of 51-L and we were going for 16 missions this year—that the question of whether we had a sufficient astronaut corps in order to handle that 16 missions and also to do the administrative work, et cetera. Would you comment on that?

Captain CRIPPEN. Yes, sir. I am not aware that anybody had a concern regarding whether we had an adequate corps. We had crews assigned for all the flights and in training, the same question had arisen that Mr. Aldrich alluded to earlier that was getting all of the software, the computer programs, out and delivered on time such that those could be put in our simulators and everybody could be adequately trained. Those were some of the things that were stacking up on us.

It wasn't a question of whether we had people; it was a question of whether we had time and facilities to get it all done.

Mr. VOLKMER. There was concern, though.

Captain CRIPPEN. There was concern.

Mr. VOLKMER. All right. Thank you.

That will, of course, have to be addressed, Dr. Fletcher, somewhere along the line if we plan to go back once into operation in the numbers that we plan to do with the number of shuttles that we have, will it not?

Dr. FLETCHER. Mr. Volkmer, even if I didn't pay any attention to Admiral Truly and Captain Crippen, that would certainly be a concern that would be fixed. But having two astronauts that have been in the program, I am certain it will be fixed.

Mr. VOLKMER. Now, the other matter I would like to address is—and it gets back to where we are now. We now have three shuttles. There is a question of whether we are going to have a fourth. I don't think anybody today can answer that question with assurance.

The statement in the recommendations of the commission in roman numeral VIII says, "The Nation's reliance on the shuttle as its principal space launch capability created relentless pressure on NASA to increase the flight rate." The next sentence is the one I was to address today, at least, Mr. Fletcher, if you could give us some idea of when we could see some activity, if any, on it. "Such reliance on a single launch capability should be avoided in the future."

Dr. FLETCHER. I think that——

Mr. VOLKMER. First, what does that mean to you, that sentence?

Dr. FLETCHER. Well, to me, it is very clear what they mean. We have already taken some action, Mr. Volkmer. They mean that we need to have a mixed fleet, a mixture of space shuttles——

Mr. VOLKMER. Expendables?

Dr. FLETCHER. Large expendables like the Defense Department what they call CELV's—we used to call it a T34D-7. Then also perhaps additional medium-sized launch vehicles like something similar to the Atlas-Centaur or Thor Delta. That is what I think is meant by that. We call it a mixed fleet, other transportation systems besides the shuttle.

Mr. VOLKMER. Now, are you addressing the question when you get into the mixed fleet and into the expendables, or are you addressing the question of whether that should be in the private sector producing those or providing those or whether it should be done through the Government as we have done in the past with NASA again furnishing the expendables?

Dr. FLETCHER. Mr. Volkmer, we are part of an interagency group which is dealing with that. It is called the Commercial Space Working Group, I believe. It is under the Economic Policy Council of the White House. We and the Department of Transportation, the Department of Commerce, and I think Defense also are working that problem very hard to decide not whether there will be commercial launch vehicles but when that should occur. It is very likely that sometime in the future we will begin to have commercially supported launch vehicles.

Mr. VOLKMER. Assuming that we do not have the fourth shuttle, we do not get it, what would you predict would be the flight rate, let's say, by 1989 with three?

Dr. FLETCHER. Mr. Volkmer, first of all, all I want to say is I don't like the thought of having only three orbiters because that is kind of a marginal fleet. It is not just the flight rate that is of concern, but it is the problem, suppose you have a brake difficulty and you want to fix it or some other problem with one or the other of the orbiters, the pressure to launch with only three might cause another accident. I don't want that to happen. Having said that, though, I think Admiral Truly can answer the specific question you asked.

Admiral TRULY. We have a fairly major effort within the program that Mr. Aldrich is running to take a look specifically at flight rate. The present status of that is we have taken an initial look without having all the data in, and I believe that we can safely build up to a flight rate with a three-orbiter fleet of 12 to 15 flights.

But I would like to make an important point to that. The difference in 12 and 15 is not a push on safety or what. It is primarily the sorts of flights you choose. For example, if you fly Spacelab, it requires a longer vehicle flow. Frankly, with the manifest that I see today, we are going to have those kinds of vehicle flows in there. So, I think we are going to be on the low end of that scale after 3 or 4 years into the program.

In the outyears, I am sure we will get smarter. There may be ways to build it up somewhat, but at least on my watch, it will be planned, as I said, and as the Commission stated in that very paragraph that you referred to, we will have a flight rate that is commensurate with our resources, be they people or dollars or work shifts at the Cape or whatever.

Mr. VOLKMER. Thank you very much. Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman. What I plan on doing is having one more colleague ask some questions, and we will cut around 5, but there is a statement I want to make before we quit to get ready for tomorrow.

The Chair recognizes the distinguished gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

The Commission has a finding, Captain Crippen, that training simulators may be the limitation on the flight rate. Do you agree with that particular assessment of the Commission?

Captain CRIPPEN. Mr. Nelson, I think that finding is associated with the statement I made earlier that it is not the simulator so much as it is the software programs that end up feeding those simulators and how fast we can get those developed and fed in. We were saturated with what we were facing this year, and there is an effort being made to streamline that. Part of it is not necessarily just the flights that you have out in front of you. It is the fact that we were also contending with manifest changes. A manifest change in effect begins to look like another flight even though you don't execute it. It was those kinds of things that we are now trying to smooth out so that we aren't faced with those kinds of problems. But that is why you are hearing rates quoted by Admiral Truly that are more along the lines of about four flights per orbiter. With that kind of thing, we can do it.

If we had some additional simulators, it would certainly help, because they are full. Also, our simulators right now, the actual basis for them preceded the approach and landing test program. Consequently, we are in need of new computers to support them, so we have some problems in those areas that you will see probably addressed in future budget requests.

Mr. NELSON. You are referring to one of the first parts of the findings in which it says that capabilities of the system were stretched to the limit to support the flight rate over the winter of 1985–86. If I recall, I saw one statistic that had STS–61C that compared to other training hours in the simulator that that crew was particularly low. If I recall, it was something like 50 hours of training in the last so many days compared to others that had 20 percent more training hours.

Is that an example of what you are talking about on the crew software?

Captain CRIPPEN. I am not familiar with the statistic you just quoted. It was an example that we were faced with more and more of the specific mission training coming later and later in flight. It was because the programs to support that training were coming later and later. I would assume that the figure that you just quoted was part of the total problem that we were addressing and why it was continuing to get tighter through this particular year when we were looking at it.

Mr. NELSON. The commission report goes on to say in addition to the software problem that you have identified, "The two current simulators cannot train crews for more than 12 to 15 flights per year."

Captain CRIPPEN. That is just the physical amount of time that you can put into simulators themselves. They can only produce so much training time, and that was why I said that if we were going to go and talk about flight rates exceeding that, it would certainly be desirable to get supplementary simulators to support it.

Mr. NELSON. Dr. Fletcher, yesterday, I took the occasion while Chairman Rogers and Vice Chairman Armstrong were here to get a clarification on their interpretation of the following recommendation: "Full consideration should be given to conducting static firings of the exact flight configuration in a vertical attitude." And that has come up here a couple of times today.

The answer that we got back from Mr. Armstrong was that that was not a requirement. It was a recommendation for consideration. In other words, they were not mandating in their recommendations that you test in the vertical attitude, but they certainly wanted you to give consideration to simulate all of the factors in the exact flight configuration.

What is your reaction to that at this point and recognizing that you don't have all the facts at this point?

Dr. FLETCHER. Well, since you addressed the question to me, it just turns out that we have had a lot of discussions with Admiral Truly and his colleagues on that subject. That is a reasonable thing to request. By the way, it has been looked at in some depth ever since I have been here and probably long before.

It is a reasonable thing to do, particularly if you test it vertically right side up. Of course, that is a little difficult because you have to have a holddown system of some kind. To test it upside down, I am not sure that is a reasonable test. Then, of course, the thrust goes up in the air.

Having said that, we are still looking at the problem and giving it the study that it deserves, and I can tell you this, that if Admiral Truly and his colleagues have come up with any good scheme for doing that, I would be surprised, but I hope I am surprised. Go ahead, Dick.

Admiral TRULY. If I could, let me tell you briefly where we are, and we can go into it in more detail tomorrow if you would like. We are already doing precisely what the Commission report said. I spoke yesterday on the phone to a couple of the Commissioners so that when we get to our recommendation, we can get to the individuals on the Commission who discussed this from a technical point of view and try to get it together.

The most important part of that recommendation is not really the difficulty of doing the test because even though it is going to cost a lot of money and take a lot of time and probably slow us down, but which is the proper configuration on the basis of technical merit that we should do the full-scale testing.

In preparation for this hearing, I spent a good bit of time on the telephone with the people who are doing that work and it is not complete, but that is precisely what they are doing. They are looking at, for example, between the horizontal and the two vertical configurations, they are looking at things like how well can you measure thrust, what sort of a range can you vector the TVC, the gimbling of the nozzle in the two configurations and, most importantly probably in this situation, the loading on the joints in the two, actually, the three configurations, what would be the best from the point of view of joint dynamics.

Beyond that, you sort of drift into the problems of it. For example, there is one other, and that is the assembly, in other words, which of the two configurations would be the proper one or the most conservative one as compared to the failure that we had.

So, I am confident that we are very fairly looking at that, and we are going to look hard at it. I believe that vertical testing could be done. We have looked at approximately 10 sites around the country that I can tell you about. We have a preliminary estimate of what we could do at each of them. It would be a mighty effort to do it, but if it is necessary to do, we will do it. But the first question is, should we do it, and that is the way we are approaching it.

Mr. ROE. The Chair recognizes the gentleman from Pennsylvania, Mr. Walgren.

Mr. WALGREN. Thank you, Mr. Chairman, and I realize it has been a long day for everybody, and I have had to be absent as well. I apologize for raising points that might have been covered, but I feel I should and I am troubled by one area.

That is this balance between looking back with recrimination or blame versus going forward. What I am concerned about is that apparently there is widespread agreement that the mindset in NASA has to change. I am concerned that the new start won't have that much of a difference unless we really do assess responsibility. I wonder whether NASA is prepared to look at this sequence of events and assess the kind of responsibility that I think would be needed to change a mindset and change an attitude.

The head of the Commission, Mr. Rogers, said that in talking to someone at NASA it was like there hadn't been any accident, and that is a direct quote from him here before this committee yesterday, and that is what I am trying to get at.

I wanted to ask, Dr. Fletcher, you said in your press release in response to the Commission's report that the criticism was not, and I think I quote, "completely undeserved." You don't mean to imply that there was an undeserved criticism in the report by that qualification, do you?

Dr. FLETCHER. Mr. Walgren, remember that that statement was made after having received the report only a few hours. I think there was maybe at most 4 hours between the time I received the report and the time I made the statement. And, naturally, you want to cover yourself. As far as I know now, there is no part of that report that wasn't deserved.

Now, that isn't to say that I have read it so much in detail that every word and adjective and so forth I agree with, because I can't really say that, but by and large, the report and the harsh criticism is deserved by NASA.

Mr. WALGREN. One of the recommendations was that there be tape recordings of some of the conferences where the decisions to launch might be made and where reservations should be made. Mr. Boehlert made the point that certainly that would create a record that you would be able to go back on, and heaven forbid that we should ever have to.

I think one of the most interesting things about that is that I sense that somehow or other the shuttle and its mission are so overwhelming that it is hard for a mere individual to get in the way. I think when I look back on some of this record, I can see the size of the project, the momentum of the project, and the importance of the project, having a kind of momentum that seems to override the individual.

I wanted to ask that that recommendation of tape recording be very deeply considered by NASA because I think the one thing it would do is it would elevate the individual and encourage them to play their role at whatever point to the fullest knowing that someone might look back on it, but not so much as a tracking device but as a mechanism to empower the individuals that are making these kinds of decisions because of the psychological momentum of the program itself. Do you have any thoughts on that?

Dr. FLETCHER. Mr. Walgren, one thing that you said earlier, I think, really is important to say again, and I will say it a different way. If we haven't learned by that tragic mistake, we haven't done our job. That is the way we learn. I am sure there were places in the organization where there was not the appropriate motivation or, as you say it, the appropriate sense of responsibility. We can't make this very complicated machine work without everybody in the decision loop feeling that responsibility and being motivated not to make a mistake.

A recording of his conversations is possibly one way we should consider to make sure that people do feel that responsibility. There are a lot of other things we have to look at as well.

Mr. WALGREN. If I might, one other question, Mr. Chairman, and that would be in one of the Thiakol memos, they talk about the possibility of a near-term fix of the O-seal problem or the O-ring problem and being based on shimming the joint differently than apparently it was planned originally. The Thiakol memo is dated August 20-something, and they say we ought to do the near-term shim fix on the flight that is scheduled after STL-25 which was scheduled to go August 22 at the time.

My point is that there was indication that there was a very near-term interim improvement that could be made on the O-ring problem. The question is whether that improvement was made on this shuttle flight that took off some 8 months later and, if not, why not?

Admiral TRULY. Do you know?

Captain CRIPPEN. To the best of my knowledge, it was not. The proper gentleman to probably answer that question is John Thomas tomorrow who did lead the accident analysis——

Mr. ROE. Well, if the gentleman would yield at that point and the gentleman from Pennsylvania would indulge me, I think that it is important to keep our continuity. I know you were at two other hearings. We are bringing those folks in tomorrow who are directly related to that. So, I think it would be more profitable to get the factual information rather than conjecture, if that is reasonable. We will take that up first thing tomorrow. I think it is appropriate.

Mr. WALGREN. I appreciate that, Mr. Chairman. Thank you very much.

Mr. ROE. I think it would be more productive. I thank the gentleman from Pennsylvania again for his excellent participation.

We are going to quit now. I want to thank you all for being extraordinarily patient and very understanding and very up front. I like that. I think there have been some difficult questions today, and I think we have all been pursuing them, and I think you have equated yourselves very, very well in the new management team that is heading up NASA.

I would hope that tomorrow, as we had discussed, we will meet at 9:30. It would be again very desirable to have Dr. Fletcher and Dr. Graham and Admiral Truly and all of you here tomorrow as we go through the next step. The next step now is to detail through the task forces you have set up and go through that drill. I think it is important for members to understand exactly what happened there which we are talking about.

I would like for you to think about this for tomorrow afternoon. I know that it would be inappropriate for you to be in a position of making policy decisions because it is not your prerogative. It is certainly not this day anybody's until all the facts are unfolded.

However, I think that as we go through the phase that we are going through now in dealing with the technological factors, safety factors, and beginning to mature some thought processes as it relates to improving the management efforts which have been discussed in depth today that the final leg of our journey is going to be what the policy positions are going to be.

There are different people, of course, who have different views as to what policy should be. Some people say we should have a balanced fleet, some people say we should not build the fourth orbiter, some people say what do we do with three if we don't build the fourth, will we be able to do the space station, what about the satellites that are sitting in warehouses now, and so forth. So, there is a universe of knowledge and fundamental basic information that has not yet been presented into the debate. Most of it has been conjecture to this point and, rightfully so, the Commission took the point of view that that was not their charge under the President's directive. I think that is a statement of fact as to where we are now.

However, I would hope that as the members unfold their questions tomorrow, those are some of the questions that should be asked so that we can begin to see in both a short-range policy point of view and a long-range policy point of view what are the facts before the Congress. In other words, it would be things such as if we have the three orbiters, why three? Why not two? Why not ten? I don't mean to be facetious. I think that is something that ought to be laid out before the American people.

I think the next point is, what is the relationship when we start talking about time and cost as it relates to the space station, the experimental phases, and the different things we are looking to achieve in the space station situation per se? The idea if you are going to be limiting, if we only have a fleet of three shuttles or four shuttles, what does that mean from an objective point of view as far as payloads are concerned, particularly in light of the safety factors and the re-review that you so well testified to here today.

So that we could get some observations, at least, factual observations based upon the information that is available to us that we can at least have some foundation for a thought process to develop by the committee as far as long- and short-range policy would be concerned.

So, I wanted to alert you to that for consideration, because some of those questions will be propounded by different members tomorrow afternoon.

I want to thank you very much for being with us. The committee will stand adjourned, and we will meet again tomorrow at 9:30.

[Whereupon, the committee recessed, to reconvene at 9:30 a.m., on Thursday, June 12, 1986.]

INVESTIGATION OF THE CHALLENGER ACCIDENT

(Volume 1)

THURSDAY, JUNE 12, 1986

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The committee met, pursuant to recess, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Robert A. Roe (acting chairman of the committee) presiding.

Mr. ROE. The committee will come to order.

Good morning, ladies and gentlemen. This is the third day in the Science and Technology Committee's series of hearings to investigate the shuttle *Challenger* accident. We have had 2 very productive days so far, the first with Hon. William Rogers, Chairman of the President's Commission on the Space Shuttle Accident, and the second with NASA Administrator, Hon. Jim Fletcher and Admiral Truly and his staff. Dr. Fletcher is back today and we appreciate his joining us again, accompanied by Adm. Richard Truly, Mr. Arnold Aldrich, and joining the NASA group for this hearing is Mr. J.R. Thompson, Vice Chairman of the NASA Task Force. In addition, we will be hearing today from the six NASA task teams that supported the Rogers investigation.

That means we're going to have 12 reports this morning, I think. I believe that our initial progress and pace has been good, and I look forward to continuing our momentum. The committee's task is to conduct an incisive and comprehensive inquiry into the *Challenger* crash, using the report of the Rogers Commission as an important basic foundation. Our objective in doing so is to provide for a constructive change in the Nation's space operation to ensure its future progress.

So again, we want to thank you, Dr. Fletcher and Admiral Truly and Mr. Thompson and Mr. Graham—Dr. Graham, rather—for your excellent cooperation yesterday. We've gotten good reports. Members feel comfortable with the progress we're making. And then, as we had planned yesterday, our program would be to take and now review in a little more depth, from a technical point of view, the work that your task force had done in coordination with the Commission to kind of close that gap between our review and your presentation. And then we would continue this afternoon on additional questions and answers, and see if we can conclude that phase of the work today.

[The prepared opening statement of Mr. Roe follows:]

OPENING REMARKS OF HON. ROBERT A. ROE

This is the third day in the Science Committee's series of hearings to investigate the Shuttle *Challenger* accident.

We have had two very productive days—the first with the Hon. William Rogers, Chairman of the President's Commission on the Space Shuttle Accident—the second with NASA Administrator, James Fletcher.

Dr. Fletcher is back today, accompanied again by Admiral Richard Truly and Mr. Mr. Arnold Aldrich. Joining the NASA group for this hearing is Mr. J.R. Thompson, Vice Chairman of the NASA Task Force. In addition we will be hearing today from the six NASA Task Teams that supported the Rogers investigation.

I believe that our initial progress and pace have been good, and I look forward to continuing our momentum.

The Committee's task is to conduct an incisive and comprehensive inquiry into the *Challenger* crash, using the report of the Rogers' Commission as an important foundation. Our objective in doing so is to provide for constructive change in the nation's space operations to insure its future progress.

America needs a sound and successful space program to carry it into the 21st Century. We are here to assure that this will happen.

Gentlemen, welcome.

I want to recognize Congressman Lujan, the Ranking Republican on the Science Committee.

Mr. ROE. Without further ado, I recognize the distinguished gentleman from New Mexico, the Honorable Mr. Manuel Lujan.

Mr. LUJAN. Thank you, Mr. Chairman. I don't have an opening statement. I'd like to move right on.

Mr. ROE. Very fine.

Dr. Fletcher, we defer to you.

STATEMENTS OF DR. JAMES C. FLETCHER, ADMINISTRATOR, NASA; REAR ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, NASA; ARNOLD D. ALDRICH, MANAGER, NATIONAL SPACE TRANSPORTATION SYSTEM, NASA; J.R. THOMPSON, VICE CHAIRMAN, NASA TASK FORCE, NASA; REPRESENTATIVES FROM NASA's TASK TEAMS: DAN GERMANY, THOMAS HOLLOWAY, JACK LEE, JOHN THOMAS, THOMAS UTSMAN, COL. EDWARD O'CONNOR, USAF

Dr. FLETCHER. I'd like to defer at this time to Admiral Truly, who will introduce his associates.

Mr. ROE. Admiral Truly.

Admiral TRULY. Thank you, Mr. Chairman.

Shortly after the accident, I recognized very quickly that what was needed was a good organization within the NASA task force, which I briefly mentioned yesterday, and I needed some full-time help from someone who could pull the task force's day-to-day activities together, and quickly came upon Mr. J.R. Thompson to my right, here. Mr. Thompson was a former employee at the Marshall Space Flight Center during the development phase; he was a project manager for the space shuttle's main engine project; and is now at the Plasma Physics Laboratory at Princeton University. J.R. Thompson agreed to come on with the task force full time and just recently, with our conclusion, is now back up at Princeton and is here today to take you through an overview of the technical investigative activities that the task force did in support of the Presidential Commission.

So I would like to turn it over directly to him.

Mr. ROE. Dr. Thompson.

Mr. THOMPSON. Mr. Chairman——

Mr. ROE. You're going to have to pull those mikes in. They're not quite as sensitive; you have to get pretty close.

Mr. THOMPSON. By way of introduction to today's agenda, I'd like to highlight and summarize the organization that Admiral Truly put together in support of the investigation conducted by the Commission. So if I could have the first chart.

With myself and Admiral Truly providing the overview, with Bob Crippen from the Johnson Space Center, Col. Nate Lindsey, Joe Kerwin, and Walt Williams, the NASA task force was structured as you see on the chart with six teams, four of which were direct analogs of teams supporting the Commission. The development production team, headed by Jack Lee of Marshall Space Flight Center; the prelaunch activities team by Tom Utsman at the Kennedy Space Center; the accident analysis team—I provided the overview leadership for that, but the driving motivator and worker in terms of getting the job done at Marshall Space Flight Center was John Thomas; the mission operations team, by Tommy Holloway of Johnson Space Center; and the search, recovery, and reconstruction team by Col. Ed O'Connor from the Air Force; and the photo and TV support team, by Dan Germany of Johnson Space Center, that you heard yesterday.

Just in terms of the end product of the work that was done by the task force, we delivered to the Commission on April 18 some 47 volumes of reports. We completed the answer to some 247 action items that were formalized by the Commission. Col. Ed O'Connor and his recovery team with the Navy, and a rather outstanding force, recovered some 215,000 pounds of debris, which represents slightly over 25 percent of the shuttle vehicle.

During the course of our support work with the Commission, we conducted some 20 different, separate, individual tests—rigs—which ended up being over 2,000 tests in terms of analyzing the data and what went wrong during the mission. This was not done just by the task force. Including many NASA people throughout the various centers and the contractor personnel at any one time, there were approximately 6,000 people directly supporting the task force, which was then supporting the Commission. So a lot of people certainly put on a lot of long hours to support this activity.

I think we came to the right conclusion. Certainly, the task force embraces the conclusions drawn by the Presidential Commission; and to get into that data, we would like to start with a summary of the time line. I think you heard from Dan Germany more yesterday on that, but we would like to summarize that, which I believe would be a natural lead-in to the accident analysis team. That presentation is going to be given by John Thomas, followed by Jack Lee and the production development team, and then the mission operations team and the prelaunch activities.

We will not present a presentation today unless you require one from the search team because of your extensive review of that hardware at the cape, but we stand by to answer any questions that you have in that area and have some backup material if you need it.

If there are any questions of me—if not, then we will proceed directly with a summary of the time line by Dan Germany.

Mr. ROE. Well, you might want to clarify for the record—if the gentleman will yield for a moment—as was explained yesterday by

Dr. Fletcher and Admiral Truly, this high-level team—teams—of expertise in these particular various assignments worked in coordination between NASA, the agency per se, and under the direction of the Commission so that the Commission's reports, efforts that we have received, is a product of these particular coordinated activities. And that, I think, we have to get on the record. I want to close that gap; isn't that what we're doing here?

Mr. THOMPSON. Yes, sir. Let me speak for the task force; that is very much true. We worked very closely with the Commission, answered, to my knowledge, any action that they gave us, and provided them quite a bit of data.

Mr. ROE. Dr. Fletcher.

Dr. FLETCHER. Mr. Chairman, Dr. Graham, of course, was here when this was going on, and I think he can clarify the relationship between the task force and the Rogers Commission. He was closer to the Rogers Commission during that time.

Mr. ROE. OK. Dr. Graham.

Dr. GRAHAM. Yes, Mr. Chairman.

When the Presidential Commission was set up, we had discussions with them as to how NASA was going to support their investigation. It became clear in those discussions early on that they intended to break their activities into a number of subcommittees. This was within the first week of their establishment. At that point, we worked with them to follow the identification of specific subcommittees and specific tasks that they were going to put together. Then when we put together our formal support teams, we mirrored the intentions and the areas that those Presidential Commission task force subcommittees were going to pursue as closely as we could. So we tried to make a structure within our own work which was closely enough a reflection of what the Presidential Commission was going to do that we could have easy and direct channels of communication between each of our groups and the subcommittees of the Presidential Commission. That was reflected in the first four working groups or task force groups that you see on the chart; the other two were then support to the entire operation, and we maintained direct communications across those under the specific arrangements that Admiral Truly set up throughout the investigation.

Mr. ROE. So therefore, the work that we're about to review now closes the gap between the expertise and the work that the NASA task force teams did for themselves and for the Commission? There's no gap between those two, no information gap between those two?

Mr. GRAHAM. There was no information gap, Mr. Chairman. We responded to all requests of the Commission. In addition, when we felt there was an area of investigation or study that needed to be done that the Commission hadn't specifically recommended, we went ahead and pursued it anyway in the technical and accident investigation area. We made the results available to them and, from time to time, we suggested to them specific issues or areas that they might wish to pursue. So we attempted to keep as close a coordination between the two activities as we possibly could.

Mr. BOEHLERT. Mr. Chairman, if I may?

Mr. ROE. The gentleman from New York.

Mr. BOEHLERT. If I just may, I'd like to ask Admiral Truly a quick question.

Was there any limitation placed on the resources that were made available to you for this important assignment?

Admiral TRULY. No, sir, there were not.

Mr. BOEHLERT. Thank you.

Mr. ROE. Dr. Thompson, you may proceed.

I just want for the members'—for the record, and for the members' information—that we've closed—there's no gap that lies between this testimony and the Commission's testimony. That's the point I want to make.

Dr. Thompson, if you would be so kind?

Mr. THOMPSON. At this point, then, we would like to proceed directly with the time line summary by Dan Germany of the Johnson Space Center.

Mr. ROE. Mr. Germany.

Mr. GERMANY. Mr. Chairman and members of the committee—the first chart, please.

This is really the second piece of the activities that the photo and TV Team worked with during the accident investigation. Yesterday you saw the film that we had, so today I want to just briefly run through the time line that goes along with that particular film that you saw, really for two reasons; one, for the record, and then to provide you some information as you go through your deliberations, and it can help you understand better some of the activities that you'll be seeing from the other teams.

Next chart, please.

This is a chart of the vehicle coordinate system that we used, and the X axis is the axis that runs along the vehicle itself. As you can see, in the front part of that, any time you have a roll maneuver, it's about that X axis. And then, the Y axis is the horizontal one that you see there. And any time you see a pitch maneuver on the vehicle, it's going to be about that particular Y axis. And then the Z axis of the vehicle is the vertical one on the chart there, and any time you have a yaw maneuver it's about that particular Z axis.

Next chart.

Now, this time line—I've got four charts that we're going to summarize for you. And let me kind of walk through the graphics of the chart before I get into the details of it.

The bar column in the middle is time, and you read it from the bottom of the chart to the top of the chart. So zero at the bottom is ignition command of the solid rocket motors, and it goes all the way up on this chart—we show 22 seconds. And each of the columns that you see, starting on the left, the column entitled "camera," just gives you an idea what each of the camera numbers are for which we've pulled the sequences which you saw yesterday. And then the next column, "photographic event," is a verbal description of what we saw from the particular—either TV or films.

The next column, MET—MET means Mission Elapsed Time—and that's referenced back to the zero ignition command. We've got that on both sides of the vertical bar because on the left side of the chart is "photographic activities"; on the right-hand side of the chart is the instrumentation that went along with the particular photography that we saw.

Now, this chart is the first one that shows the first activities that were anomalous from a photographic point of view that has to deal with the smoke, and at 0.678 seconds there, you see we confirmed smoke. And then we talk about the multiple puffs of smoke that happened. And after that, at 2.7 seconds and 3.3 was the last time we saw the smoke.

Next chart.

Mr. ROE. Would it be profitable for the people that are here, if somebody had a pointer and was just pointing this out as we went along? I think that might be helpful, because everybody doesn't have the advantage of having a copy of your——

Mr. GERMANY. OK. Crip, would you mind pointing?

Now, this particular chart indicates that, really, nothing was happening in that second period of time from the 3.3 seconds up to 58 from a photographic point of view.

Mr. ROE. Mr. Germany, can I interrupt you again?

Mr. GERMANY. Sure.

Mr. ROE. Let's go back to the first chart and start over again.

Mr. GERMANY. All right.

Mr. ROE. I think it's very important because the first phase on the left-hand side, where we're talking about the photographic events, you're in effect following in sequence here, in chart form, what we viewed yesterday by photography.

Mr. GERMANY. That is correct, sir.

Mr. ROE. And it might be well just to reiterate that as we're going on because it gives a sequence that's very important to later-on conclusions, if you don't mind doing that over again.

Mr. GERMANY. OK.

At 0.678 seconds is where the first time that we saw the smoke. And then, from 0.8 up to 2.4 is where we saw the multiple puffs that you saw on the film yesterday. And then at 2.7 seconds was the last time we saw smoke above the right SRB ET attach ring. And what that is telling you is that, if it was no longer above it, that means essentially the smoke was not replenishing itself, so the joint was tending to heal itself.

So the next point up, at 3.3 seconds is when you see the last positive visual indication, and it's below the ETF dome. So now the vehicle is moving, and you no longer see anything going in the plus-X direction; so therefore, the joint has essentially healed itself for this particular time period.

OK, next one.

So during this period of time here, from 35 up to 54, we're seeing nothing from an anomalous point of view.

Next one, Tommy.

OK. From 58.7 up to 64.7 is where we see the next series of events that occurred. And what's happening in this series is, the first evidence of flame occurred at 58.7 seconds. And let me just kind of verbally describe what this chart is going to tell you here.

The flame started, the first time we saw it, and then it started to flicker a little bit. And as it—from a flickering point, it became continuously and well defined at 59.2 seconds, so that's telling you the flame is progressively getting larger and is becoming constant. And then, later on, at the 60.2 second period is where it is attaching itself to the ET 2058 ring frame. Now, what this is telling you is that now the flame is impinging upon the ET, and from this point on is when you're going to start to do the damage to the external tank itself.

The result of that is shown at 64.6 seconds—Crip, if you could—right there, is the first indication of the leak at the 2058 ring frame. So this is telling you now that the external tank is beginning to leak as a result of the impingement of the flame upon the tank, OK?

Next chart, please.

So the leak has started now, and we didn't really see anything else from an anomalous point of view from that point until we get to the 73.1 second point, and that is the LH–2 tank failure. When the LH–2 tank failed—and if you'll look at the right-hand side of the chart, Crip, at 72.2, start the divergent yaw rates—the R means right and the L means left—the difference between the right-hand booster and the left-hand booster. Now, the right-hand booster is starting to move away as it broke off, and you saw—you remember the CAD picture yesterday, when we saw it rotating like that? So the booster is breaking away, and the LH–2 tank has failed.

Now, here's what's happening. When that LH–2 tank fails, you have a large—the hydrogen itself is coming out of the bottom of the tank. You get a little bit of an extra thrust rippling up through that structure. The right-hand SRB is starting to move, and it crunches into the inner tank area, as you saw yesterday; and when that happens, you lose the structural integrity of the external tank. And when that occurs, there's nothing to hold the vehicle together, essentially, because it's all tied together through the external tank. So that point on is when we get the—the structural breakup occurred, which we call the point at 73.3 seconds, greatly increased intensity, the white flash. This is where we feel the structural breakup occurred.

And I believe that's the last of the charts, and that's just a brief summary for you, Mr. Chairman. Are there any questions?

Mr. ROE. Are there any members that have a specific question on this first phase?

Mr. WALKER. Yes, Mr. Chairman.

Mr. ROE. Mr. Walker from Pennsylvania.

Mr. WALKER. First of all, Mr. Chairman, I do have a statement here that I would like unanimous consent to put in the record.

Mr. ROE. No objection; so ordered.

[The prepared opening statement of Mr. Walker follows:]

OPENING REMARKS OF

REPRESENTATIVE ROBERT S. WALKER
RANKING REPUBLICAN MEMEBER
SUBCOMMITTEE ON SPACE SCIENCE
AND APPLICATIONS
U.S. HOUSE OF REPRESENTATIVES

JUNE 12, 1986

Good morning, Mr. Chairman. Today we move into a more detailed analysis of the Challenger accident. We have now heard from Secretary Rogers and have had the opportunity to read the report his commission has submitted to the President. We have also heard from the highest level of NASA management that they endorse the commission report.

Last night the President of the United States indicated that he will seek a new orbiter to replace Challenger. That is good news for those of us who firmly support our space program.

Having sat through several days of hearings and having read a great deal of material to get ready for these hearings, let me share some very important observations with you.

"Any program, and particularly the largest and most complex research and development program ever undertaken by man ... must have schedule goals. The schedule is an essential and significant management tool -- without it the program would require more and more time and more and more money."

"Safety must be considered of paramount importance in the manned space flight program even at the expense of target dates. The earnest declaration that 'safety is our prime consideration' must be transfused into watchfulness so that people do not again stumble into the pitfall of complacency. NASA's creation of a Flight Safety Office with broadened capabilities and better lines of communication is a step in that direction. The Congress, in the National Aeronautics and Space Administration ... authorization act, directed the Administrator to appoint an Aerospace Safety Advisory Panel to review NASA's operational plans and advise the Administrator with respect to the hazards of proposed or existing facilities, proposed operations, and on the adequacy of proposed or existtıng safety standards."

"It is not our intention to have the committee intrude unnecessarily in NASA's daily management responsibilities or to substitute congressional judgement on the innumerable matters requiring decision by the program managers. It is a practical impossibility for the committee to review all communications between NASA and its contractors. Clearly NASA must exercise discretion in determining what information it will call to the attention of Congress."

"Nevertheless, the committee's investigation demonstrated that NASA must make a more concerted effort to alert Congress to major problem areas as the space program evolves. The serious contractor deficiencies noted ...

should certainly have been reported to the committee at the time of the ... budget hearings, if not before."

"We are disturbed at the possibility that, had there been no disaster, important shortcomings in the management, scheduling, design, production, and quality control might never have come to light."

Mr. Chairman, those observations are important because they are direct quotations from the report of the Senate Committee which investigated the Apollo 204 Accident which occured on January 27, 1967.

Mr. Chairman, I am astounded how accurately those words from two decades ago apply to the situation we face today. Just a few short blocks from NASA headquarters is the building that houses our national archives. Engraved on the face of that building are the words of the philosopher who wrote, "Those who do not learn from the past are doomed to repeat it."

My concern, Mr. Chairman, is that history does not repeat itself, but people can repeat history. The Congress, and more specifically, this committee, has a duty to sear into the institution memory of NASA that these errors cannot, and must not be repeated.

Mr. ROE. Do you want to turn those lights on for the moment?

Mr. WALKER. There is that long period of time, or a fairly substantial period of time, between the first puff of smoke and then the visible flame. Do we have a theory about what happened there? You said the joint appeared to heal itself. Do we have a theory about what that process was, of the healing? And then what ruptured the joint again at approximately the 62 second point?

Mr. GERMANY. Mr. Walker, let me do this for you. I'm going to give you a little bit of an answer, and then Mr. Thomas, who is going to be following me on the accident analysis team, will go into it in more detail. But since you ask it now, I'll give you part of the answer right now.

As the smoke occurred and the erosion started of the O-ring, we believe that what happened, a combination of the exhaust products and the vehicle dynamics stopped the twang in the vibrations after that first three seconds. It tended, then, to seal. And then, as it went later into flight, if you go through the MAX-Q region, which is maximum dynamic pressure, the vehicle starts the oscillation and the vibration again——

Mr. WALKER. When does that start?

Mr. GERMANY. Well, MAX-Q occurred—let me just, so that I won't have to guess the exact answer for you—MAX-Q occurred at 59 seconds, maximum dynamic pressure. After that point, then we feel the erosion began again, and that accounts for that. Now, Mr. Thomas will go into more details for you if that satisfies you right now.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. ROE. Further questions? The gentleman from California.

Mr. PACKARD. Thank you, Mr. Chairman.

I think we've understood that the crew had no way, nor did ground control, have any way of knowing the progress of this 73 seconds in terms of the anomalies. That's correct, isn't it?

Mr. GERMANY. Yes, sir, that is correct.

Mr. PACKARD. There were no monitoring systems that would have alerted them to the progress.

At what point in time would—well, apparently there was no point in time where they could have shut down the motors——

Mr. GERMANY. No, sir.

Mr. PACKARD [continuing]. And stopped the process of going, even had they known?

Mr. GERMANY. That's correct.

Mr. PACKARD. They would have either had to have aborted and cut the shuttle away from the rest of the hardware, had they known, but that would have been the only thing they could have done, no way to have salvaged the mission.

Mr. GERMANY. That's correct. We didn't have anything at all that would allow them to correct the situation or to leave the situation.

Mr. WALKER. Thank you.

Mr. ROE. Mr. Barton.

Mr. BARTON. Thank you. I just have two quick questions.

One, based on what you just said, how close, in spite of all the screw ups, did the mission come to not disintegrating? And two, if it wasn't—were there some unusual wind shears that caused excessive—I think you call it maximum-Q—that if it had been a normal wind situation, that wouldn't have occurred? Does that make sense to you?

Mr. GERMANY. Well, I'm not sure I follow the questions directly, but the——

Mr. BARTON. I mean, it appears that there was a chance, in spite of the cold temperature—the ring did seal, and for a certain amount of time everything was working OK.

Mr. ROE. If the gentleman would yield, I think it would be more profitable—we've only seen the first blush; we're going to have an analysis presented by the accident analysis team, and it might be better if we listened to what their analysis is, because the questions that we're generating now relate to that issue, if that is satisfactory to the members. I think it would be more profitable, and we would at least have the full background before us. Is that all right?

So why doesn't the gentleman hold on his questions?

Mr. BARTON. I would like an answer to the first question.

Mr. ROE. All right.

Mr. BARTON. If they feel that the mission came close to being successful, in spite of all the problems.

Admiral TRULY. Let me try and—the answer is no. We don't know how the leak would have continued to grow had the vehicle not broken up where it did, but I know of no analysis that said that we could have sustained that unknown—that leak that was growing at an unknown rate until separation, and that the axial thrust caused by the exhaust at the time of separation would have also created an unknown separation condition at the time of solid rocket motor separation.

So the task force never was able to develop any conclusive data that would have shown that the mission could have been a success. You could postulate that, but we had no data.

Mr. ROE. All right.

Under those circumstances, I believe you will—is your next plan to have the accident analysis team's observations presented by Mr. Thompson?

Mr. THOMPSON. Yes, sir.

Mr. ROE. Suppose we proceed with that.

Mr. THOMPSON. OK, John.

At the time of the accident, Mr. Chairman, John Thomas was the manager of the Space Lab Program at Marshall, and he was instrumental in providing the leadership for this accident analysis team. And with the conclusion of our work, he is now leading the redesign activity on this joint on the solid rocket booster.

Mr. ROE. Mr. Thomas.

Mr. THOMAS. Thank you, Mr. Chairman.

Mr. ROE. We'll have to pull those microphones closer because we're having difficulty hearing. And it's not your fault; it's the microphones' fault. We're hoping NASA will design a new one for us in due course along the line.

Mr. THOMAS. OK.

Could I have the first chart, please?

Mr. Chairman and members of the committee, I'd like to discuss with you today our activities within the task force dealing with the topic of accident analysis.

Next chart, please.

And to set the stage for doing that, I would like to describe for you the approach utilized in the accident analysis process. It was structured from the very beginning, observing the incident, obtaining the flight data, the photovisual coverage and the observations from the flight. From that, we developed a fault tree, and that fault tree was constructed using the data from the incident, the anomalies we did observe early on, the observable vehicle failures—that is, the explosion—and all the failure sources that could produce such——

Mr. ROE. Will the gentleman please suspend? We have a call of the House. I don't want to lose the continuity, but your testimony is too important and I want to keep it in continuity. So we will have to recess for 10 minutes and vote. And if everybody would please come back right away, because in 10 minutes time we're going to proceed to go through this program in depth.

[Recess.]

Mr. ROE. Again, the committee will reconvene. We were just about to begin with the presentation by Mr. Thomas. If you'd be so kind as to begin again, sir.

Mr. LEWIS. Mr. Chairman. Mr. Chairman. Over here, Mr. Chairman.

Before we start, I think it should be noted that our senior astronaut lost his position to an electronic pointer. [Laughter.]

He was pointing out on the charts where the presenter—now he's lost out to an electronic pointer. That just goes to show you the advance of technology.

Mr. ROE. I missed that. OK. Are we ready?

Mr. THOMAS. Mr. Chairman, I was in the process of defining the analysis approach that we implemented in the accident analysis team, beginning with the incident. And from the incident, developing a fault tree that included the anomalies, the vehicle failures, and the source of those failures, and that was for each and every element that was aboard the 51-L flight.

Having defined the fault tree and the potential sources for cause of the failure, then we developed an incident data base, an accident data base, consisting of a large amount of design and qualification data, the assembly tests or assembly and build tests and checkout data, determined the flight environments, the data that was received from the flight on the downlink, and other data from the ground, the various tests and analyses that had been conducted and would be conducted in the future in a closed-loop fashion, as well as the recovered hardware and a detailed listing of anomalies that had been experienced in the past.

Having this data base, then, we reviewed the data base and developed from that a number of scenarios that would have led to a structural breakup of the vehicle. We postulated the sequence of these scenarios and then evaluated their credibility. And in evaluating that credibility, it required that we do additional testing and analysis, which is also shown in the process, where we had special tests set up, special analytical models developed, as well as those that were existing at the time. And then we took the results of those, fed those back into the data base, and then cycled back through the scenarios. Having then an iterative process of testing credibility of each one of the scenarios, finally winding up with conclusions of what we suspected to be the causes and the findings of the accident analysis panel.

Next chart, please.

Then to carry out this process, we established an organization that is listed under J.R. and myself in the top block. We established a group for each of the major elements; that is, the shuttle main engine, the external tank, the solid rocket motor, one for the solid rocket booster, and for those things that transgressed across all of those systems, a systems working group. We also treated the payload, which was an inertial upper stage and the TDRS satellite. We then had recovery support involvement down at KSC, and we kept very close with that. The photo analysis support was very important in this process in determining events and the times of those events to supplement the downlink instrumentation.

In addition, the orbiter was thoroughly reviewed. The installation process, as well as the analytical process leading to payload installation into the orbiter, was reviewed and the Goddard Space Flight Center reviewed the TDRS and the other payload aboard 51–L, the Spartan. That is the major payloads that were in the bay.

This group met—could I have the next chart, please? This group met continuously, were in session continuously, from the time of the accident. There were preestablished contingency plans in place for each one of these groups; they were implemented, particularly for the major elements, within hours following the accident, and were in session up—even prior to the formation of the task force, and then we carried forth with those. The task force was established in early March, and from that point forward—you can tell in the middle of the chart there those areas where we met with the Commission and preceding each Commission meeting, we had a very regular session with our counterparts on the Commission, called the accident analysis panel.

Now, the other major milestone within this scenario of events is the 18th of April, and that's the time that the report was prepared and submitted.

Could I have the next chart, please?

Now, proceeding into the analysis itself and the findings, first I would like to give you some very summary level findings, and then from there I will progress to describe each one of the findings and later on determine—or show to you the determination of the various failure mechanisms that caused the seal to leak.

The first finding, of course, is that the right-hand aft field joint leaked hot combustion gas, and that was from the solid rocket motor, of course. And the second event, as Mr. Germany pointed out earlier, was that that leak contacted the external tank and weakened or penetrated the hydrogen tank. The hydrogen tank then was breached by this penetration or weakening, and it then initiated the process that led to the structural breakup of the total stack.

And also in these findings, we determined that there was no other element of the STS or its payload which contributed to the cause of the accident.

Now, if I could take those one at a time, and begin with the solid rocket motor description on the right-hand chart. You will see the solid rocket motor up at the top. It is assembled at the factory in casting segments, of which there are four. You see the forward segment, and then aft, and those segments at the factory have what are called factory joints, and they are covered over with insulation and propellant, as delivered to the launch site. At the launch site, the solid rocket motor is assembled using these four segments. And as each segment is joined, there is a field joint; and the field joint, as shown by arrows emanating from each of the three, it shows a cross section of the field joint down below that.

Mr. ROE. May I interrupt you and ask you a question, there?

Mr. THOMAS. Yes, sir.

Mr. ROE. Is the configuration and the structure of the factory joint the same material makeup, other than the sealing insulation on the outside, as would be the field joint?

Mr. THOMAS. Yes, sir.

Mr. ROE. In other words, it's still an O-ring type of configuration, but it's sealed in the factory?

Mr. THOMAS. Yes, sir.

Mr. ROE. Thank you.

Mr. THOMAS. On the left screen I've shown a colored cutaway of the field joint, and if I could start on the right-hand side of that, is the propellant in the red; the insulation in blue; and there is a liner that is shown in gray, there. The brown between the insulation is vacuum putty, and the metal parts then, are shown—the clevis, which is in orange, and the case tang, which is in purple; and the O-rings that seal those two metal parts are in green. The joint is pinned together around a given joint by 177 pins that are shown in this schematic in yellow. Those pins are held in place by a metal band that goes around the circumference of the total vehicle, holding those pins in place, and that is covered over with cork, that is shown in green. You can see the leak check port also, in a lighter brown, that is utilized to leak-check the two O-rings.

This joint configuration is the one that failed, and the failure mode was that the gas came through—our analysis is that the gas came through the putty, between the insulation. The O-rings leaked; the gas then either went down around the tang in this direction, down here, and out, and as the metal heated, up—or the hot gas exited here—the hole then became larger. Or, as the gas came down and out this area right here, and the tang was overheated, and the emanation of the hole was at that point. At any event, the hole—which I will describe to you shortly—began at this joint.

May I have the next chart, please?

This is a photograph of the recovered hardware from this particular right-hand aft field joint, and the photograph is taken looking from this direction into the—from inside out. It is the top part, here, represented by this schematic. This is the hole here, and that is what one can view here. These are the pinholes, as you can see, those pins right there, on this side and along the bottom here. The white is the insulation; this black is the propellant as it has burned forward, and this is the actual melted metal.

This is at approximately the 300 degree position on the spacecraft.

Next, please.

This is the lower half of this joint, that is, this part, depicted schematically here. This is the hole that goes from this point to this point, and that's approximately 33 inches. Again, the propellant, the insulation, and the metal. There is a secondary hole in the metal at this point that we believe occurred or penetrated very late; in fact, after the 73-second time period, due predominantly to recirculation around the external tank attach ring on the outside. It was, we feel, an outside-to-inside burn through.

May I have the next charts, please?

On the left is a sketch of the vehicle looking forward, with the right-hand solid rocket motor here, and the leak that I was just talking about from a circumferential standpoint occurred at this point right here, then contacted the external tank in this radial location, and from then forward to the dome, then exited the external tank. And that, longitudinally, is slightly around on the other side of that solid rocket motor.

Next, please.

I mentioned that we had prepared a fault tree for you earlier, and I have shown that at a very summary level on these two charts that are on the screen now. If I could just briefly explain the two screens.

This one is the total summary fault tree, as you can see. It has the orbiter, the main engine, the payload, the external tank, and the solid rocket motor. This chart on the right screen takes these two elements of the fault tree and gives you an indication of the next tier or the next level of detail that was postulated that could have caused the failure.

The color code with respect to understanding the chart, the green represents an improbable cause; the red, a probable cause; and the yellow, a possible cause. And this fault tree, we started—in fact, you start and go backward in the development of a tree and test it, then in the opposite direction. We started with the total breakup. We observed the external tank breakup, and then we postulated those things that could have caused that, the orbiter, and so forth. Then the next level down would be to determine what within, for example, the external tank could have produced that observation there, and that was damage at liftoff, premature—that is the range safety system, called a linear shaped charge—destruction, a structural flaw, or an overload could have caused structural breakup of a tank. And, in fact, we cleared all those as not being the cause of this accident.

Then one would move down to the solid rocket booster and again consider loads; consider that the integrity of the pressure vessel was violated, and it also has a range safety system aboard. And we determined that it was not at fault.

The red, then, the way one would follow this logically, is from here to here to here, and then back down, and then you get finally down to the point that we have a joint seal anomaly.

The conclusion is, then, that there were no other contributors to the accident other than the solid rocket motor, and the solid rocket motor joint leakage.

Now, what would then cause the joint to leak? And these are the factors that we determined to contribute to that leak. That is, the gap opening due to joint dynamics, and I'm going to go into these a little bit further; but this first one, the dynamics; the joint temperature at launch, affecting both resiliency of the O-ring and the potential for ice in the joint; the joint damage and/or contamination during the assembly process; O-ring squeeze after mating—that is, as has been referred to, it's also a static O-ring compression—putty performance, which is a pressure-holding capability, also referred to as pressure actuation time; assembly blow-holes, which can produce O-ring erosion. I'd like to take each one of those individually and describe it for you.

Next chart, please.

The gap that I have reference to when I say the gap opening is as shown right here, at the upper left-hand corner of this screen. This is a cutaway of the joint. In the static condition, the joint is in this configuration, relatively straight from tang to clevis, and the O-rings are located in here and the gap is the gap between the—this land between the O-rings, the O-rings and this tang. As the motor pressurizes, the ends of the clevis and the end of the tang tend to bow in this direction. And this is—the internal pressure, of course, is on the left side of the tang and clevis. This bows out, this bows out, and you put a bending moment in the clevis which causes the tang to move away from this inner clevis leg at this point, therefore, opening up the O-ring gap. That is what has been referred to as gap opening, and also rotation of the joint.

Depicted also on the curves is time in thousandths of a second, and this is the gap opening at these points right here for the primary O-ring, which is located in this slot, and the secondary O-ring, located in this slot. And as you can see, as the motor pressure builds up with time, these gaps begin to open and open at a fast rate, between 200 and 300 milliseconds after ignition, and finally wind up with the primary O-ring gap opening as much as 27 to 29 thousandths and the secondary opening on the order of 15 to 17 thousandths. And we believe that these, in fact, have a probable influence in the cause of the accident.

Mr. BARTON. Mr. Chairman, could I ask a question there?

Mr. ROE. The gentleman is recognized.

Mr. BARTON. Is that the normal performance of those O-rings, or was that the performance during the accident?

Mr. THOMAS. I'm particularly describing the metallic part of the joint at this time, and it is normal. The O-rings in this case, which I will talk about a little bit later, in theory and in design should track that opening.

Mr. BARTON. OK, but that is a normal occurrence in the flight, right there?

Mr. THOMAS. That is.

Mr. LUJAN. Mr. Chairman, I have a quick question.

Mr. ROE. The gentleman is recognized.

Mr. LUJAN. Is the maximum pressure time—pressure from inside the tank—is that concurrent with the maximum turbulence time?

Mr. THOMAS. No, sir. The maximum pressure is immediately—right after ignition, and it drops downward as you go toward the area—or the regime—of maximum dynamic pressure. Once through that, it builds back up slightly.

Mr. LUJAN. OK. Thank you.

Mr. ROE. The gentleman will proceed.

Mr. THOMAS. The—it should be noted also that this aft joint is the—the aft joint on both sides of the vehicle—is, in fact, open less than those that are forward, and that is normal, as well. But we do conclude that this is a potential cause, in combination with the other effects, for the accident.

If I could have the next, please.

Joint temperature is, of course, a factor that must be considered. Tests show that the O-ring resiliency significantly decreases at the temperatures experienced on STS 51-L. The cold O-ring would not track the gap opening rate without pressure assist, and what I mean by that is that the pressure assist is pressure from the motor getting in the O-ring groove and forcing it to a closed position. There must be room in that O-ring groove for the pressure to enter that groove and provide the pressure assist.

On the right-hand chart, I've shown the temperatures for the two lower joints, the aft field joints, for both vehicles, both SRB's, the right and the left. The little insert up at the top shows the radial clocking on the right-hand solid rocket booster; the left—and as you can see, the right-hand solid rocket booster temperature around the periphery varied in the way that is shown here from about 30 degrees at that position; it built up as we go around between 90 and 180 degrees, and drop back down. The reason for this is—this is at time of launch, but at the time of launch, the sun angle was about from this direction, which put the sun on this side of this solid rocket motor. On the other side, it was shielded, on the left-hand side, and as you can see that was a relatively steady temperature, on the order of 30 degrees plus or minus 2 or 3 degrees.

Analysis and tests indicated also that at these temperatures, that ice could be in the joint, and that would be formed from water that penetrated the joint during a rainstorm or inclement weather while the vehicle was on the pad. And we did show by analysis that ice could be at that location within the joint, and further tests showed that if ice was there, and should it freeze, it will unseat the secondary O-ring.

I think it is needed to be pointed out that most all of the 51-L joints up the vehicle tended to follow this same temperature distribution pattern around the vehicle, although they would be slightly warmer.

So we conclude from this that the joint temperature is a probable contributor to the cause, in conjunction with other factors.

Next, please.

During the assembly process, with the tight tolerances that we must maintain, there is the potential for some damage to the O-ring or the metal, or there is the potential to create contamination that could affect the sealing performance. With respect to tightness of the tolerances at the locations that would be experienced during the 51-L, I've shown each one of the joints as they appear on the stack. The top one is the right-hand motor; the lower is the left; again, with the clocking. This location here on the right hand—as I've shown with this arrow—is the location where one would expect—either at this location or the one 180 degrees opposite—are the locations that one would expect damage during the assembly process, if it occurred because this is the location of the maximum ovality as measured during the mating process between the two segments.

You can see that this one is the worst; the others are less than that, as you look around the other five joints. Even with this process, we looked to see if there had been metal-to-metal interference, and analytically it would appear that there is no potential for overstressing the components, should that have existed.

We also showed that by some subsystem testing, subscale testing, that contamination could be produced at that joint, but we had to work at it a great deal in order to produce that contamination.

We have had some very, very limited experience of O-ring damage in ground tests; however, we believe that to be associated with the ground test assembly process and not necessarily directly applicable to the flight motor. But ~~in~~ any event, it was possible to have created the contamination or damage, but we believe that with the care that was taken and with the dimensions that we actually measured, that it was improbable that contamination contributed to the 51–L accident.

Next, please.

A very important factor to be considered, particularly in conjunction with cold O-rings and their resiliency, is the squeeze—that is, the degree of compression—of the O-ring around the joint. It should be noted also that, at this location where I pointed a minute ago that the maximum potential for damage could occur, this is also the maximum point of squeeze on the aft field joint for the right-hand motor, and that is also the point where we observed the leak, around the 300-degree position around the vehicle. So we find that these conditions, with this maximum dimensions, could produce max squeeze on the O-ring.

Now, if one puts max squeeze on the O-ring, this then reduces the pressurizing volume that it might have within its groove, and as we have shown by subsystem testing, an initial gap between the O-rings and the tang of 20 thousandths, which was considered to be the nominal prior to 51–L, it would seal down to 10 degrees. And I guess I should stop now and explain my color code.

The green is that the test that we performed would pass. The yellow as that we would have some leakage, but it would finally seal, and the red indicates that the joint would not seal at all. Down the left-hand side are the temperature ranges for which we tested; across the top are the pressures reaching the O-ring at the time of ignition, and the right-hand column is that the pressure is delayed some 200 to 500 milliseconds, which is associated with putty, that is the next topic.

This is the squeeze of 4 thousandths on the O-ring. This is a nominal squeeze of 20, and if we can direct our attention to these two columns right here, it would show that with a 20 thousandths initial gap, that the joint would seal down to 25 degrees and there would be, then, the potential for some leakage, but it sealed down into this area; but it would not pass when we tested lower than zero degrees.

With an initial gap of 4 thousandths—if I could skip one line for a second—4 thousandths, which is maximum squeeze, it showed that the joint—the confident sealing of the joint was only down to about a temperature of 55 degrees, and in this 40 to 50 degree region, there was a question of whether it would finally seal. And then below 40 degrees, it was shown by these subscale tests that it would not.

Now, these subscale tests are not finite in their discrimination, but they do give one enough information to describe the relative thresholds at which passing or failing would take place.

In order to test the squeeze theory—that is, that the tighter the squeeze, the higher the operating temperature must be—we installed some tests which I do not have shown on the right-hand chart, but showing that with a 10 thousandths gap, that it would seal down to 25 degrees, which says that the threshold is somewhere—on the squeeze—from 4 to 10 thousandths of an inch.

There is one other——

Mr. LEWIS. Mr. Chairman.

Mr. ROE. The gentleman.

Mr. LEWIS. Might I ask when this squeeze test data was obtained?

Mr. ROE. The gentleman is asking when was the squeeze test data obtained.

Mr. THOMAS. This particular data was obtained post-51–L accident. It was during the investigation process.

Mr. LEWIS. So you have nothing to compare it to prior to the investigation?

Mr. THOMAS. No, sir, we do not.

Mr. LEWIS. OK.

Mrs. MEYERS. Mr. Chairman, could I ask a question?

Mr. ROE. The gentlelady from Kansas. He's almost finished, but the gentlelady from Kansas. Go ahead.

Mrs. MEYERS. Well, in previous damage to the O-ring, because it had shown up in previous flights, had you been able to identify what was causing the trouble? Was it a squeeze or a burn or——

Mr. THOMAS. Earlier in the—those that you have reference to, I think, is the erosions and blowby earlier in the program, before 51–L?

Mrs. MEYERS. Yes.

Mr. THOMAS. Those were attributed, in every case, to a blowhole where the O-ring was eroded, to a blowhole in the putty that allowed a hot gas jet impingement or hot gas jet to impinge upon the O-ring and erode it.

Mrs. MEYERS. So that—when you talk about the squeeze problem, that is a result of the cold temperatures?

Mr. THOMAS. The squeeze, per se, is a result of the dimensions of the two mating motor cases and the mating process, how they come together.

Mrs. MEYERS. I understand that, but you had said that the squeeze was not a factor previously, and so did that have something to do with the cold temperature?

Mr. THOMAS. When I answered the previous question I did not intend to mean that it was not a factor previously, that it was not known to be a factor previously, prior to 51–L.

Mr. ROE. Well, if the gentlelady will yield now, I want to finish this because we're losing continuity. I want to finish this continuity, and then we'll have ample time to get into depth because I know—I see here that there's a series of questions that should emerge here, and the gentlelady is right on target. But I'd rather wait and put them into context or we're going to lose—we're going to be all over the lot and we're going to lose the context that I'm trying to create for the record. So if you would please bear with me, the gentleman would conclude.

Mr. Thomas.

Mr. THOMAS. Thank you.

There is one other factor in this O-ring squeeze scenario that surfaced during the investigation, and that is that the cases, the case walls and diameters, appear to grow slightly—on the order of, say, 20 to 30 thousandths after four to five uses; this was determined during the investigation process, and that must be reckoned with for the future.

The maximum squeeze is considered a probable cause, in conjunction with other factors.

Next, please.

The last factor that is considered to be in the probable category is putty performance, and tests showed the potential for putty to delay O-ring pressurization during the ignition process; however, that performance is variable. Sometimes it would delay the pressurization and sometimes it would—a hole would become in the putty, and it would pressurize immediately. This was further substantiated by the presence of blowholes in the putty prior to 51-L, and in 16 of the 138 joints. We also determined, during the investigation and the destacking of STS 61-G—which was a vehicle that was stacked after 51-L—it was found that several of the joints in the 61-G contained blowholes, which would have occurred during the assembly process, of course. Tests confirmed that delayed pressure actuation could result in failure of the seal. If it holds the pressure off by 250 to 500 milliseconds, the joint would fail at the max squeeze conditions and at the low temperatures. And that's shown in the right-hand column of the chart on the right. Again, the green is pass. If we have maximum squeeze at 55 degrees, we delay the pressure 250 to 500 milliseconds; then it will—with 4,000 squeeze, it will pass down to 55 degrees and down to about 40 degrees with nominal initial gap opening. But lower than that, the seal would not pass.

So putty performance is a variable, and it is considered in the probable category.

The last slide, please.

We could not determine that any single causing mechanisms—that is, those that we just discussed—could be discerned. The damage and contamination at mating we believe to be improbable, but it takes a combination of others to form the most probable cause of the 51-L accident, and those are the gap opening, the O-ring squeeze, the low temperature—either involving O-ring resiliency, or ice in the joint—and the variability of putty. And the conclusion was that the joint must be redesigned to eliminate the effects of these conditions.

And that is all I have, Mr. Chairman.

Mr. ROE. I want to thank the gentleman for an excellent, indepth presentation.

I think that we again have to vote, regrettably. Is the gentlelady from Kansas still here, Mrs. Meyers?

What we'll do—because you were developing a good point—what we will do is to recess again so we can keep the continuity going, recess for 10 minutes. We'll vote and return immediately, and then the Chair will defer to Mrs. Meyers to continue that process she was on in reference to the pressurization. So you'll be up first when we return.

So we'll recess for 10 minutes.

[Recess.]

Mr. ROE. The committee will reconvene. Members, I'm sure, are delayed, unfortunately, on the floor, but we're going to go on.

What I would like to do at this point, in view of Mr. Thomas' presentation, I think that there has been considerable questioning that has emerged, as you know, over the last 3 or 4 days since we've begun the hearings in the specific area of this—in the specific area which we're discussing, and I think it would be profitable for us to review four or five of the elements that people have on their mind, and be done with this part of the issue as to really what happened in the accident per se, vis-a-vis the relationship of the O-ring plus temperatures and the other areas that we have been discussing. I know we have other representatives that have further testimony to give—Dr. Thompson—but we'll take that up as we go along today.

Now, having said that, for the record I would like this question just to get it into the record for anyone who chooses to answer it. Maybe, Dr. Fletcher, you might want to direct one of your folks.

During the course of the photography that we reviewed yesterday, at 0.678 seconds, the black smoke was observed and there were seven or so puffs that followed, caused by—and then the question is, the burning of material. And now, for the record, what material do you believe was burning at the time?

Mr. THOMAS. Mr. Chairman, we believe that material that was burning was the insulation that is shown as NBR on that joint photograph, and the grease, and possibly the O-ring to some extent.

Mr. ROE. The question that follows on that answer, and that's the answer that comes from the Commission's report—given that the insulation is designed to protect the casing, how could it burn?

Mr. THOMAS. The insulation was eroding; and by eroding, it burns down a little bit and flakes off, and burns down and flakes off. And in that process, it releases it and provides the insulation.

Mr. ROE. The final question to this, for the record. Given the small volumes of the O-rings and the grease per se, how could so much smoke be produced, quantitatively?

Mr. THOMAS. I speculate, Mr. Chairman, that that was the NBR, and there are ample amounts of NBR, the insulation.

Mr. ROE. The insulation. All right.

Now, in the course of the testimony that we've had, starting with Dr. Thompson and then yourself, Mr. Thomas, filling in, the areas that were covered fundamentally which I want to concentrate on are the joint situation, the weather situation, the putty situation, and in effect, I wrote down to myself, the torque situation, meaning the change of pressure because of the dynamics of the vehicle itself on the O-ring. OK? Those are the areas that people now are beginning to want to get into in more depth so that we can lay to rest once and for all any doubts and questions—and answer any questions, hopefully—that these folks may want to ask at this point, to get upon the record. Do you understand where I'm coming from?

Now, therefore, I will defer to the ranking minority member, Mr. Lujan from New Mexico.

Mr. LUJAN. Thank you very much. Thank you.

Mr. Thomas, there is one thing in all of the readings and studies that comes to mind as something that might have happened, and I haven't heard anyone talk about it yet. My understanding is that when you begin to stack everything together, you first stand the solid rocket boosters up—you know, pointing up—then you add to that the external tank, and then you add the shuttle onto that. Is that correct, the way that it's all put together?

Mr. THOMAS. Yes.

Mr. LUJAN. I further understand that after the external tank is put on, it is then filled with the fuel. Is that correct?

Mr. THOMAS. Yes, sir.

Mr. LUJAN. And that at the time that it is filled with the fuel, it is already attached to the solid rocket boosters. When it is filled, when the external tank is filled, the coldness of the fuel makes the external tank contract. My understanding is that it's 4 inches that it contracts.

When it does that, of course, it's got to pull away from the solid rocket boosters 2 inches on each side, assuming that it's all equal. Could that contribute—because the damage was near the struts that hold the external tank and the booster together—could that pulling away, those 4 inches by contracting the external tank, have contributed to the weakening in that general area? Was that studied in the entire process that you went through?

Mr. THOMAS. Yes, sir. We revisited all of the stacking loads as the vehicle was assembled to determine if there was anything in the process that caused us to exceed our design allowable limits, and that the stack configuration, as it sat on the pad with the propellants loaded, was analyzed. And it was determined that there were no unexpected or unusual loads produced prior to the 51-L liftoff.

Mr. LUJAN. Well, but we've had the damage at that joint all the way along. My question is, is there a spring or something—if you're going to move 4 inches, something's going to give somewhere, where that strut is attached on both sides, whether that could be a contributing factor to the other 13 times that there was damage inside the joint.

Mr. THOMAS. I don't recall specifically what the shrinkage radially of the tank is, nor what it is longitudinally, but in the longitudinal direction is where it shrinks the most; that is, it gets shorter. And that is taken—the deflection there is taken into account by having the struts slightly at an angle, such that when it does shrink, they are up at the proper horizontal angle. And the preloading in the struts is accounted for in this shrinkage calculation, both radially and longitudinally. I just don't happen to recall the numbers, sir.

Mr. LUJAN. The struts aren't rigid?

Mr. THOMAS. The struts are hinged at each end.

Mr. LUJAN. So that the up and down would be compensated for with those hinges—well, I'm not sure, now, whether it's 4 inches that it shrinks in circumference or not. My understanding was 4 inches; now, it may be from top to bottom rather than——

Mr. THOMAS. I'd be happy to provide that for the record, sir.

[Material to be supplied follows:]

Material requested for the record on page 48, line 1162 by Mr. Lujan on June 12, 1986.

The external tank (ET) shrinks in both longitudinal and radial dimensions as it is loaded with cryogenics prior to launch. The shrinkage is accounted for in the external tank to the solid rocket booster (SRB) strut configuration and design loads. The forward struts are designed for longitudinal loads and remain stationary during loading. The AFT struts are for lateral (radial) loads. They are initially at a seven degree downward angle (SRB to ET) and move to a horizontal position as the ET is loaded. The seven degree angle change is equivalent to the longitudinal shrinkage of four inches. Unconstrained ET radial shrinkage is 3/4 inch. However, due to the strut configuration and loads, the physical radial shrinkage is 3/8 inch.

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. ROE. I thank the gentleman from New Mexico.

May I ask for just a clarification, again for the record. As I understand it, when the O-ring—the joint and O-ring system was originally designed, that the understanding from an engineering point of view is that upon launching of the vehicle, that the torque or the pressures that were put up—I would say torque at that point—literally help to seal the O-rings. Wasn't that the original conception in the early, original design?

Mr. THOMAS. That is my understanding.

Mr. ROE. That is what I think we heard testimony to. And then it was determined, after a point in space—you'll pardon the euphemism; a point in time—it was then determined that instead of that occurring, that those pressures that evolved during the course of launching literally pulled away from the O-ring and worked the opposite. Do you recall that discussion?

Mr. THOMAS. Yes, sir.

Mr. ROE. When was that—when was that latter phenomenon discovered?

Mr. THOMAS. I don't remember the chronological time, but it was around the time that the structural test article was tested at Marshall. It's in the late 1970's, I believe.

Mr. ROE. That's what I'm trying to get at. So it was determined, from an engineering design point of view at a given time in space in 1977 or whatever, that instead of the pressure on those O-rings working "X" way, it was just the opposite during the launch because of countervening pressures, and it worked the opposite way? Is that a factual statement?

Mr. THOMAS. That's my understanding.

Mr. ROE. OK. I think that's important to keep in mind.

The Chair recognizes the gentlelady from Kansas, Mrs. Meyers.

Mrs. MEYERS. Thank you, Mr. Chairman.

I—several of us up here, I think, were confused about the O-ring squeeze, and I thought that when the two parts were put together, that it was actually opened wider so that then the O-ring would not fill the gap and prevent the gases from going through, and that's why I was asking the question, and was wondering whether that equipment had ever been involved before, or shown that kind of damage before.

Mr. THOMAS. Regarding your first understanding there, as the two halves are mated, the squeeze on the O-ring around the circumference of the sealing surface will vary, but not to the point that it would create a gap between the O-ring and the sealing surface. It's just a differential amount of squeeze as you go around the vehicle on the O-ring. So from that standpoint, it's not a problem during the stacking process. What turns out to be a problem is that if you have maximum squeeze on the O-ring—that is, maximum compression—in conjunction with cold temperatures, that is when the O-ring performance or the joint performance to seal degrades, because the fundamental problem with that is that you cannot get pressure behind the O-ring to actuate it to seal and the cold weather has prevented it from being resilient enough within itself to follow the opening of the gap as it rotates or as it opens during motor ignition.

Mrs. MEYERS. OK.

Was the putty part of the original design, or was that something that was added later to protect the O-ring?

Mr. THOMAS. It was in the original design, for that purpose.

Mrs. MEYERS. As I understand it, Mr. Chairman, there was a briefing last August at NASA headquarters in Washington about the O-ring problem and Morton Thiokol briefed people in Washington about the O-ring problem. Who was at that briefing?

Dr. FLETCHER. You're asking people that weren't at headquarters at the time. We may have to supply that for the record, unless somebody in the back row—can you?

Mr. THOMPSON. I believe Mike Weeks was the senior man at that meeting, and Mike is here today.

Dr. FLETCHER. Mike Weeks is here, Mr. Chairman.

Mr. ROE. Well, that's a statement of fact. Would you provide for the record who was at that meeting? I think that would be adequate.

Dr. FLETCHER. Yes, sir.

[Material to be supplied follows:]

Material Requested for the Record on Page 52, Line 1247, By Mr. Roe on June 12, 1986.

Attendees at the August 19, 1985, O-ring Briefing at NASA Headquarters:

MORTON-THIOKOL
J. E. Mason
C. C. Wiggins
J. C. Kilminister
A. J. McDonald
C. A. Speak
F. J. Ross

MSFC
L. B. Mulloy
R. Schwinghamer

HEADQUARTERS
L. M. Weeks
D. L. Winterhalter
W. H. Hamby
R. Bardos
P. F. Wetzel
P. N. Herr
H. Quong

Mr. ROE. I'm trying to stick to the technical questions, now, so that we don't lose the continuity. OK?

Mr. BARTON. Mr. Chairman, I think that is a very important question, though, about who was at the meeting and what they were told.

Mr. ROE. If the gentleman would yield, there are a plethora of important questions just to be asked. What the Chair is attempting to do at this particular session, while we have the expertise here, is to take and establish a series of factual events as to the issues involved. We've got all afternoon and days and days to expand on that. While we've got these technicians that have been flown in from all over the country, I don't want to lose the value of those technicians' knowledge; while we're asking questions that are germane, I want to deal with this issue today so that members clearly understand the technical issues so we don't have to go back and revisit it 500 times, and then we're going to get more work done.

Mrs. MEYERS. Could I ask one more technical question?

Mr. ROE. Yes, of course you can.

Mrs. MEYERS. I think it was indicated in the report that the putty may have been dislodged or may not have stayed in place because of the testing once the rocket was put together. Is that accurate?

Mr. THOMAS. After the segments are mated and they have the putty in between the joint, there is a leak check of the O-rings that is performed using the leak check port between the O-rings, which is pressurized to two pressure levels. An initial pressure is induced into this small cavity between the O-rings, of approximately 200 pounds per square inch. That is to seat the O-ring. It is dropped back down to 50 PSI and locked up and monitored to see if there is a loss of that pressure, indicating an O-ring leakage. There was a postulation that this high pressure, the 200 PSI, may have blown by the O-ring before it seated, and then been trapped by the putty, and then continued to blow through the putty, creating a blowhole prior to ignition. And we have not been able to determine whether that is fact or not. That was only a postulation.

Mrs. MEYERS. Thank you.

Mr. HENRY. Would the gentlelady yield on that point?

Mrs. MEYERS. Yes.

Mr. HENRY. Thank you.

My understanding was that as the O-ring sealing problem became more and more increasingly apparent, that the pressurization levels were increased as kind of a fail-safe check on the seals. And as you increased up to 200 pounds per inch, as a preflight readiness and inspection you may have potentially negatively affected the putty variability. Am I correct?

Mr. THOMAS. That is what the statistics show.

Mr. HENRY. So you have a counterproductive safety program, as it were. The safer you tried to make it by that means, the more likely the accident, if we understand the problem correctly.

Mr. THOMAS. Well, I think it's important to note that the higher the pressure, the more the incidence of O-ring distress. But it did not appear to make that distress on an individual O-ring, to my recollection, worse.

Mr. ROE. The Chair recognizes the gentleman from New York, Mr. Scheuer.

Mr. SCHEUER. Thank you, Mr. Chairman.

Mr. Thomas, according to the Rogers report, "Prior to the accident, neither NASA nor Thiokol fully understood the mechanism by which the joint sealing action took place." We know there were a number of early warning signals from 1983, two different warnings in 1985 up to NASA headquarters, so they had an impressive body of evidence there that things had gone awry, that there was a very real problem that needed to be addressed.

Now, I'm impressed by the report that you have assembled in the short 6 weeks since the tragic *Challenger* accident. I'm very impressed by the enormous data base that we now have about the O-rings, the faulty O-rings and the field joint behavior. I'd like to know, how much did it cost to accrue this information since *Challenger*? How much personnel did NASA assign to that? And above all, for goodness' sake, why wasn't this work done after repeated early warning signals that emanated from Marshall but did go up to NASA central headquarters on at least three occasions, as outlined in the report, so that they were alerted, they should have known. My question is, Why wasn't the remarkably fine work that you and the others have done in the last 6 weeks done before the tragic accident so that, as Admiral Truly testified yesterday—if this knowledge that you've accrued after 6 weeks of brilliant and dedicated and highly professional effort had been available to Admiral Truly and other decisionmakers before the *Challenger* launch, that launch certainly would have never taken place.

So since they had the knowledge that things had gone awry, why didn't they do over a period of several years what they've done very professionally and very successfully over a period of only a couple of weeks?

Dr. FLETCHER. Mr. Scheuer, I'd like to start that question. As you know, once an accident has occurred you can put your best talents and your large amount of resources in investigating that particular accident. Before the accident occurred, perhaps we should have been alerted, as you suggest, and——

Mr. SCHEUER. Let me interrupt you, Dr. Fletcher. It's not a question of, you should have been alerted. You were alerted.

Dr. FLETCHER. I'm sorry, I——

Mr. SCHEUER. In 1983, information came up to NASA headquarters in Washington that things had gone awry. L. Michael Weeks signed a waiver of the fail-safe requirement for the joints, and headquarters was fully informed about the lack of redundancy in the joints. Then, in July 1985, in a memorandum from Irving David, it further shows that headquarters was again alerted to the seriousness of the joint problem, and in August 1985, Michael Weeks and others at headquarters were briefed again about the repeated failures of the O-rings. So you were alerted; so this isn't just a problem of communications.

There are plenty of fingers of blame, if we are in the business of fingerpointing. There are plenty of problems with decisionmaking at Marshall, and undoubtedly they should have taken corrective action based on the information they had. But it seems to me that we cannot exculpate NASA's central headquarters from a major share of responsibility here by saying, if they were alerted. You were alerted. Why didn't this effort, this remarkably effective and professional effort that we've done in a matter of 6 weeks—why didn't this take place in 1985? After the third warning that something was very much awry with the O-rings and the seal?

Dr. FLETCHER. Excuse me, Mr. Scheuer. I didn't mean to say, if I did, that we were not alerted. I'm just saying that maybe we should have taken that sort of intensive action at the time. And by the way, I think that your earlier statement is quite right; headquarters was at least as much to blame as other parts of the organization. I don't think all of the responsibility should reside just at the Marshall Space Flight Center, and I have said that and I think everyone else that I know has said the same thing.

Mr. SCHEUER. I'd like either you or Mr. Thomas to tell us, how much did this effort cost that was made in the last 6 weeks to accrue this remarkably impressive data base? How many people were involved in the effort? How much did it cost?

Mr. THOMPSON. Here, let me try to answer that. We've discussed that within the task force, and there's a lot—well, there's not a lot of rigor in this number, so let me just try to give you a ballpark estimate. And if you're interested, I'll try to go back—or get NASA to go back—and try to——

Mr. SCHEUER. Well, you're using up valuable time, Mr. Thompson.

Mr. THOMPSON. It's about $5 million. About $5 million would be my estimate to run the tests that we conducted during this investigation.

Mr. SCHEUER. During this 6 weeks?

Mr. THOMPSON. During about the 6 weeks where we maximized the test activity.

Mr. SCHEUER. How many professional and scientific people were involved in that?

Mr. THOMPSON. In the conduct of the test, in the analysis of the test?

Mr. SCHEUER. Yes.

Mr. THOMPSON. I'd say in the range of 200 people.

Mr. ROE. Would the gentleman yield for a moment?

Mr. SCHEUER. Well, of course I'd yield, Mr. Chairman, but I can't help remarking——

Mr. ROE. I'm going to give you more time later.

Mr. SCHEUER. I yield, Mr. Chairman.

Mr. ROE. I'm only trying to do something here, and I'd ask you to suspend on that because otherwise I would be breaking the continuity of my own arrangements.

What I'd like to do is to ask Mr. Scheuer to suspend for a moment because, obviously, these questions are going to lead in this direction. What I want to get on the record at this point, so we can be done with it, is there any other member here now that wants to ask a technical question on the basis of the data that we have before us? We have information that's been presented; we're not through with this, but that's the prelaunch and the other safety areas that follow. This is the heart of the technical testimony. And we've talked about the field joint; we've talked about the weather issues, the relation thereto; we've talked about the putty—

there's other questions on the putty; we've talked about the high pressure. So what I'd like to do is use this time for any member, in that order, first to get that on the record so we are done with revisiting 50 times the same question over and over and over again, and then go from there and recognize Mr. Scheuer to begin, and then from Mr. Scheuer back to the gentleman from Texas, because we started in that direction.

Mr. NELSON. I have a technical question.

Mr. ROE. The gentleman from Florida is recognized.

Mr. NELSON. OK.

Mr. Thomas, now, there seems to be an inconsistency, and I want you all, Mr. Thompson, to straighten this up for us. We had testimony—first of all, let me start with the Commission report.

The Commission report says that one of the contributing factors was the fact that the casing of the SRB was out of round, and you all have measured this. You have measured it on a number of flights; indeed, we find that there was an out of round on 61–C, as well. And in the way that you have presented the data to us here today, the way the Commission has structured their report, that is an implication of one of the factors that contributed to the failure of the joint.

Where the inconsistency comes in is that we have had testimony or information to our staff, specifically last Thursday at the Cape from a Mr. Carver Kennedy, who says that once you mate the clevis and the tang, insert the pin, and then insert around the circumference 177 of the clips in the pins, that that actually causes a circularizing in the joint so that the implication is that you would eliminate the out of roundness once the clips are inserted in the pins.

Now, the question is, Mr. Thompson, Mr. Thomas, what is correct?

Mr. THOMAS. Mr. Nelson, I believe that the process that you just described with the installation of the pins and the insertion of the shims——

Mr. NELSON. Shims?

Mr. THOMAS. Shims.

Mr. NELSON. Are you talking about the pin? Is that one and the same?

Mr. THOMAS. No.

Mr. NELSON. The clip?

Mr. THOMAS. The clip.

Mr. NELSON. The clip? OK. You call it shim? S-H-I-M?

Mr. THOMAS. Right.

Mr. NELSON. OK.

Mr. THOMAS. When you put those in, that tends to round it, but it cannot go all the way because those shims are of a constant thickness all the way around, and they are not sized to take up the total amount of gap around the periphery of the vehicle. So it tends to round it, but it can never go all the way toward the rounding process.

Mr. PACKARD. Would the gentleman yield on that specific point?

Mr. NELSON. Yes, I will. I want to—before I lose this, I want to make sure that the measurements that you gave us at the cape last Friday, as well as today that you've repeated, where you show the differences in the roundness on the different segments, and you show that in the diagram of the circumference—you measured that out of roundness before you put the shims in, before you put the pins and the shims in. Is that correct?

Mr. THOMAS. Before we mated.

Mr. NELSON. OK. So conceivably the shims then, as you just stated, will cause more circularizing or rounding, once you put them in. Is that correct?

Mr. THOMAS. Yes, sir. To a degree, it is going in the right direction, toward rounding.

Mr. NELSON. OK. All right.

Are you saying that by the putting in of the shims in the pins, that it does not completely correct the out of round condition?

Mr. THOMAS. Yes, sir.

Mr. NELSON. How do you know that?

Mr. THOMAS. Because dimensionally, the width of the gap of the clevis plus the width of the tang in the clevis plus the dimensional tolerance variations around the gap, around the circumference, in addition to the thickness of the shim, do not present a total, even thickness of tang, O-ring, and shim equal to the width of the clevis. There is what I call a "rattle space" in there, a small space for the tang to move back and forth. And the thickness of the shim is thirty-two thousandths, plus or minus a couple of thousandths——

Mr. NELSON. I thought the shim was an eighth of an inch thick. It's not?

Mr. THOMAS. No, sir.

Mr. PACKARD. Would the gentleman yield?

Mr. NELSON. Thirty-two one-thousandths?

Mr. THOMAS. Thirty-two thousandths. That's this small clip I'm pointing to right here; it's thirty-two thousandths.

Mr. NELSON. That's thirty-two one-thousandths of an inch thick?

Mr. THOMAS. Yes, sir.

Mr. NELSON. So let me then summarize, and I'll yield to the gentleman.

What you're saying is that when you put 177 shims in 177 pins around the circumference of the SRB segment, that it helps solve the problem of out of roundness, but it does not completely solve it and it very well may be that you'll still have metal on metal——

Mr. THOMAS. Yes, sir.

Mr. NELSON [continued]. Caused by the out of roundness of the casing?

Mr. THOMAS. Yes, sir.

Mr. NELSON. Is that a fair summary?

Mr. THOMAS. Yes, sir.

Mr. NELSON. I yield.

Mr. ROE. The gentleman from California.

Mr. PACKARD. I thank the gentleman for yielding.

To followup, at the same time that the shims do correct as much of the out of roundness as it is capable of doing, it creates at the same time a strain on the joint, in the metal of the joint, does it not?

Mr. THOMAS. Not perceptively. It compresses where it——

Mr. PACKARD. Well, anytime that you correct an out of roundness you are creating some strain on the metal that is out of round, when you move it toward roundness.

Mr. THOMAS. Yes, sir. And that—it does produce that, but it's not of a great magnitude. That's the only point I was making.

Mr. PACKARD. And that pressure between the metals—and sometimes, where it even gets to metal-to-metal—is what we have been shown to be this squeeze problem, create the squeeze problem; and particularly, coupled with cold weather, that the O-rings have not the resiliency to return back to reseal when there is that squeeze as a result of the out of roundness or the stress of metal to metal.

Mr. THOMAS. It's the out of roundness.

Mr. PACKARD. Is the strain at the O-ring point, or is the strain at other points in that effort to correct the out of roundness?

Mr. THOMAS. The only strain that one might see—and I think, again, it's imperceptible—is the amount of strain that you might put into the motor case wall by having it flexed slightly to install the shim. The predominant squeeze that is put into place is squeezing of the O-ring, which does not induce any stress at all into the tang or clevis.

Mr. PACKARD. In the design of the O-ring under these very conditions, where we're trying to mate the two parts together, and if there is strain or if there is the creating of a roundness in the mating process with the shims, is there movement of the O-ring in there as that takes place, as the seating takes place, so that if there is strain, that the O-ring has the capacity to adapt itself to that strain?

Mr. THOMAS. The O-rings are, of course, elastomeric material themselves, and they have good strain capability. But more importantly is, they are completely covered with grease, and that grease will allow the O-rings to move as——

Mr. PACKARD. So in the groove that the O-ring is placed in, it can slide in that groove rather freely? It is not kind of pressed in there and locked in, into a single position, without the flexibility of movement?

Mr. THOMAS. Yes, sir.

Mr. PACKARD. I thank the gentleman for yielding.

Mr. ROE. All of that notwithstanding, the state of the art, as you expressed it so well, it still is moveable?

Mr. NELSON. Mr. Chairman, I'm not through yet.

Mr. ROE. Just a moment. The gentleman from Texas has a question, but I believe that—are you finished yet? The gentleman from Florida?

Mr. NELSON. No, sir; I had yielded.

Mr. ROE. Oh, OK. Well, the gentleman from Florida is recognized.

Mr. NELSON. I just want to get some additional clarification on this.

Since you have told us that the measurements that were reported in this handout—that's not the one. There's a chart like that someplace where you've got each of the segments, and you've got the gap. And if I recall, in some it was four one-thousandths of an inch; in others, it is twenty-one thousandths. Is that correct?

Mr. THOMAS. Yes, sir; I think.

Mr. NELSON. All right. But you said that is a measurement before you put the pins and the shims in?

Mr. THOMAS. Right.

Mr. NELSON. Since we're concerned with the gap at the time of ignition—which is, in fact, once the pins and the shims are in—where do you have that kind of calculation? What is the gap then, in inches?

Mr. THOMAS. We could not tell precisely what the gap was at the ignition point of 51–L. What we did during the investigation process was destack STS–61–G. And our intent there was, No. 1, we knew what the measurements were as we stacked the vehicle; and then, before we began the destacking process and during the destacking process, we made several hundred measurements of all of the joints on the vehicle. And what our intent was, was to determine, No. 1, were we inducing any strange or unusual stresses into the clevis legs or other parts of the joint? And more importantly, could we predict where this maximum squeeze might take place?

On the left hand, I believe, is the one we spent so much time on—on the left hand, we determined that there was, in fact, some maximum squeeze, almost metal-to-metal, on that joint as would have been predicted based on the premated measurement. But what surprised us a little bit is that we could not precisely pinpoint its location circumferentially. It was dislocated 90 degrees from where we would have thought it would have been.

Mr. NELSON. And in measurement of inches, what was that gap where you called it the maximum squeeze?

Mr. THOMAS. About a thousandth of an inch.

Mr. NELSON. About one one-thousandth of an inch. And you interpolate from what you measured on 61–G, when you destacked—you interpolate that to 51–L?

Mr. THOMAS. We think there was the same type phenomena there.

Mr. NELSON. OK.

Thank you, Mr. Chairman.

Mr. ROE. The gentleman from Texas.

Mr. BARTON. Thank you, Mr. Chairman.

Mr. ROE. These are technical questions. This is the last technical question before the Chair recognizes the gentleman from New York.

Mr. BARTON. No, my question is not a technical question, Mr. Chairman.

Mr. ROE. No, no. This gentleman from Texas. Mr. Andrews. I beg your pardon.

Mr. ANDREWS. I accept. My question is technical.

On June 11, the committee submitted some written questions to NASA. One of those, I'd like to ask the group, if you would expand on it a little bit for us.

The question was, "Was there a qualification test call-out in the design specs for the solid rocket booster joints?" Your answer was, "There were no qualification test call-outs in the design specs for the joint per se. There are, however, design specs and verification requirements for the performance of pressure seals and the structural elements."

Now, I guess the question is, were there any qualification specifications for the joint seals? Yes or no?

Mr. THOMAS. I did not pursue that particular question during the analysis process.

Mr. ANDREWS. Well, can you answer that question?

Mr. THOMPSON. We're going to cover that a little later in Jack Lee's discussion. But in the qualification tests of the assembled motor, obviously that thing—after the firing in the inspection, then you should pick up any anomalies in that area at those joints.

Mr. ANDREWS. All right.

Mr. THOMPSON. Now, specifically what was done in the joint area relative to the qualification, I believe that that's probably going to be covered in Jack's discussion in terms of what the specification calls for, what was done by test, and what was then augmented by additional analysis. So I believe if you can wait on that, we'll get to it.

Mr. ANDREWS. I'll be glad to wait to expand on it, but do you know the answer to the question? Is the answer yes, or is it no?

Mr. THOMPSON. Were there specific qual tests done on the joint? I'm not aware of them at a large scale—you know, at the full motor scale, no. To my knowledge there were not.

Mr. ANDREWS. So your answer is no.

Mr. THOMPSON. Well, let's just take a minute and let Jack come up and directly answer it.

Mr. ANDREWS. Thank you.

Mr. LEE. Would you repeat the question exactly?

Mr. ANDREWS. We submitted a written question on June 11. The question was, "Was there a qualification test call-out in the design specs for the solid rocket booster joint?"

Mr. LEE. OK. The answer to that question is, in the design spec there is not a specific qualification test requirement for the joint. However, there is a requirement for certifying that the joint meets certain specifications. You do this in a number of different ways—qualification tests; you may do it by similarity; you may do it by development tests, or analyses. So there is a requirement for certification of that joint, and this joint was in fact certified to those requirements, with some qualifications.

Mr. ANDREWS. Well, just to be sure I understand. If you had a motor here—you're suggesting that there was a test made of the entire motor; but that in terms of the joint itself, the critical joint, no tests?

Mr. LEE. There was no qualification test. There were a number of special tests and development tests associated with the joint, but not associated with the full qualification—the qualification to cover the full regime of all requirements. There were a number of tests performed, either in development, qualification, and special tests.

Mr. VOLKMER. Would the gentleman yield on that?

Mr. ANDREWS. I'd be happy to yield.

Mr. VOLKMER. Could you furnish the committee copies of all documentation of the qualifications for the joint?

Mr. LEE. Yes, sir.

Mr. VOLKMER. And the criteria and certification?

Mr. LEE. Yes, sir.

Mr. VOLKMER. We'd like to have those.

Mr. LEE. Yes, sir.

Mr. VOLKMER. Thank you.

[Material available from committee files.]

Mr. ANDREWS. Thank you, Mr. Chairman.

Mr. ROE. All right; we'll have that file for the record.

Now we have just one——

Mr. PACKARD. Mr. Chairman, are you still on technical questions?

Mr. ROE. If the members would give the Chair a chance, they have all been given ample opportunity to be heard, and I will get to the next witness. Yes, we're still on technical questions. What I'm trying to do now is seal off the technical questions so we can go on and start from there on the processes that were handled.

Now that the gentleman from Texas has concluded, the Chair will now recognize the gentleman from Utah, Mr. Monson, who has a technical question he'd like to ask.

Mr. MONSON. Thank you, Mr. Chairman.

With regard to the field joint temperature, do you have a specified limit as to what that can be before launch is allowed to go forward?

Mr. THOMAS. Yes, that's my understanding.

Mr. MONSON. It's a calculated temperature? It's not a temperature that is taken through some mechanical means?

Mr. THOMAS. For STS-51-L, those temperatures are calculated, placed on an ambient measured value.

Mr. MONSON. Obviously, those limits were not exceeded on that flight, then?

Mr. THOMAS. To my knowledge, the calculated limits—or the ambient conditions—were used for the launch process.

Mr. MONSON. Now, the chart indicates that, at the location of the leak, the temperature was somewhat less than 30 degrees; I don't know how to interpolate it exactly, but it's my understanding it was to be qualified to fly at 31 degrees. Is that correct?

Mr. THOMAS. Pardon me just a second.

Admiral TRULY. Mr. Chairman, while we are getting the answer to that question, I thought it might help to point out that the reason—the conversation between the two gentlemen who were head of the task teams was the way we organized the investigation. Mr. Thomas' team was to determine the cause of the accident, and Mr. Jack Lee's team was to get into the development and the production; in other words, the requirements and the certifications and so forth.

Mr. ROE. I understand that, but we're bound to have a little overlapping so that we can get on with it, to a point.

Now, are you finished, Mr. Monson?

Mr. MONSON. I need my answer.

Mr. THOMAS. It's 26 degrees.

Mr. MONSON. It's 26 degrees?

Mr. THOMAS. That's the specification value, and the——

Mr. MONSON. And the chart indicates it was somewhat very close to that.

Mr. THOMAS. The calculated values at the joints were approximately 28 degrees, thereabouts.

Mr. MONSON. Now, you also indicated earlier that you've discovered that the casings expand after flights, and I assume that they don't return to their original size; is that correct?

Mr. THOMAS. That is correct.

Mr. MONSON. Does that in any way indicate that you will not get as many flights out of these casings as you originally thought you might get?

Mr. THOMAS. We don't believe that to be the case right now. We think that this growth that I have described is a function of the proof pressure testing; that is, bringing the motor up to the maximum—in excess of the maximum—expected operating pressure right after the manufacturing process to screen out flaws. In doing that, we think that after approximately the first three to four proof cycles, that the growth will cease to exist, and then they can be used as usual throughout their normal life.

Mr. MONSON. You don't have any experience in that area, though, yet? Is that correct?

Mr. THOMAS. We have not completely resolved that issue.

Mr. MONSON. Thank you.

Thank you, Mr. Chairman.

Mr. ROE. The gentleman from—I'll give the gentleman from California an opportunity in a moment, but Mr. Lujan from New Mexico, please.

Mr. LUJAN. I am confused as to what Mr. Lee's answer was. My understanding—and part of your briefing will show qualifications not accomplished to the required spec limits—my understanding was that there was no analysis made on the effects of temperature on that joint, that Thiokol was supposed to do an analysis but that when you went back and checked all the data, you found that that analysis had not been made.

Now, did I understand your answer just a little bit ago to Mr. Andrews that that analysis had been made?

Mr. THOMAS. Sir, could I defer that until Mr. Lee comes up, immediately following me?

Mr. LUJAN. Well, he's answered the question, and apparently it is completely different than my understanding is.

Mr. ROE. The Chair would ask Mr. Lee to come up here now because if this is in limbo, let's get it squared away right now.

Mr. LEE. OK. Let me go through a little more explanation. I understand some of the confusion here.

There is a requirement on Thiokol in the contract, in the specification, to certify—design and certify—the joint to a number of requirements. Now, to certify, you can do that by qualification testing, development testing, special testing, or by analyses. In the case of the seal joint per se, the requirement to certify, if you will, the joint to the full range of specification requirements imposed on them—and this is by a Johnson Space Flight Center document which is imposed on all of our contractors—it's around a natural and induced environment. The natural environment requirement ranges from 31 degrees Fahrenheit to 99 degrees Fahrenheit. The induced environment, which means after you've got the external tank loaded and so forth—this can range, under those same environmental conditions, from 26 degrees Fahrenheit to 120 degrees Fahrenheit.

Now, in reviewing this process with Thiokol, they did not interpret these requirements, either the induced requirements or the environmental requirements, to mean for vertical flight. They interpreted these requirements to be in a storage configuration.

And then to take it one step further, in reviewing how they satisfied all of their requirements relative to performance, sealing capability, and so forth, we found that an overall performance of this joint was required to be demonstrated by qualification tests, by development tests, and by flight tests. That requirement was associated with a temperature of 40 degrees to 90 degrees mean bulk temperature of the propellant from sea level to 200,000 feet. That's an overall system requirement; we didn't take issue with that. There's a requirement for the sealing capability—and by the way, they did, in fact, qualify these; they did it with about six demonstration motors, full scale motors, and three or four qualification motors, and the lowest temperature of any of those was, I believe, 36 degrees.

Another requirement for verification of this seal was associated with the sealing capability of the O-rings themselves, and this requirement did not impose a temperature limitation, if you will, but was more to demonstrate that the O-rings did, in fact seal; they were redundant; and that they had a leak test port to be able to verify, from an acceptance standpoint, the integrity of these seals.

The third part of this systems specification, if you will, has to do with the imposition of the natural and induced environments, the 31 to 99 and the 26 to 120. This was specified to be accomplished by analyses. Now, the contractor proposed that, Thiokol, and the Marshall Space Flight Center accepted that. The issue comes in on the fact that they did not interpret that to be an in-flight requirement. They did not do a detailed analysis or test to verify that during the flight regime. There was, in fact, analysis done that turned out to be, in hindsight and in light of the issue of the lack of understanding of the joint and the temperature issue and so forth—the analysis that was performed was not adequate, and I think the Commission report points that out; not specifically about this issue, but the inadequacy of the overall certification and qualification program.

The analysis that was in fact performed was the review and insurance, by inspection, that the O-ring—the O-ring material itself—met a certain MILSPEC, and I have that number but a certain MILSPEC. The significant part of that MILSPEC is that it should meet—be able to be usable from a temperature range of minus 30 to 500. And on that basis, they considered that analysis to be—that is part of an analysis which should, in fact, qualify or certify that particular joint.

So the issue here—I mean, if you want to look at the uncertainty of why this issue was brought up relative to the qualification, is that in light of today's understanding, that was not adequate and the fact that the Thiokol Corporation misinterpreted or did not interpret that range as NASA did.

Mr. LUJAN. Mr. Chairman, you're pushing me—and that's fine—so we can move on ahead, but we'll pursue that this afternoon, I guess.

Mr. ROE. I would suggest the following. We're getting out of kilter here a little bit. We've had a good continuity and want to keep continuity. I knew this was going to happen, and part of the question was, when? There are obviously other technical questions that other members wish to ask, and the Chair is going to recognize all of them in due course, and I want to assure each member that his interest or her interest is respected. It is almost 12:30 and, as I promised I'm going to do, I'm going to defer now to my good friend from New York, Mr. Scheuer. When Mr. Scheuer is concluded, we will break from our hearing, return at 1:30. If Mr. Scheuer needs additional time at 1:30, he will be up, No. 1. If he wants to suspend and wait for other members to bring more of the technical matters out, that's what we'll do.

And the second point, as far as our witnesses are concerned, we would then defer to Mr. Lee because I see it's now important to bring in your next phase because it's overlapping, and I think that's—in fact, I don't think—that is the direction that we will follow.

The Chair now recognizes the distinguished gentleman from New York who has been eminently patient, the distinguished Mr. Scheuer.

Mr. SCHEUER. Well, thank you, Mr. Chairman. I must confess that I have a sense of abiding inferiority in not being able to cope with all these technical and scientific questions.

Mr. ROE. But the redeeming factor is, you have the floor. [Laughter.]

Mr. SCHEUER. Well, I've never been very good at science or math; as a matter of fact, I have to take my shoes and socks off if I want to count to 20. But here we are, and let's get back to some of the policy questions we have been wrestling with.

I think we were discussing a few minutes ago that since the accident 18 weeks ago, and since the task force on the O-rings was set up, over a 6-week period we spent about $5 million, and about 200 scientific and technical personnel produced this extremely impressive body of evidence that we now have that really answers an awful lot of questions about the O-rings and the failure to achieve adequate sealing. Is that more or less what we've decided?

Mr. THOMPSON. Yes. That was my estimate, in terms of the resources——

Mr. SCHEUER. Very good. And I think the record also was clear, and I think Admiral Truly testified to this yesterday, and without putting words in your mouth I would assume you all agree that if we knew before the launch what we know now, after this expenditure of $5 million that was put together—this technical knowledge base by 200 scientific and technical people, that there never would have been that tragic launch, OK?

Now, what I'd like to ask is—the perfectly predictable follow-up to this, after the repeated warnings of maybe 14 or 15 failures of the O-ring on a number of flights, and after these three warnings in February or March of 1983 and in July of 1985 and in August of 1985, warnings that went right up to NASA's nerve center in Washington, how much in the way of resources, both funding and personnel, did you apply to solving the perfectly self-evident problems of the seal and the O-rings before launch?

Dr. FLETCHER. Mr. Scheuer, I'd like to start out again on that one, even though I wasn't here. I think we want to differentiate between dollars and numbers of people, and the quality of people. Yesterday we talked about the new giants in NASA; the folks that are here today are those new giants. Admiral Truly has picked people from all over NASA to do this investigation, and these are truly unusual people.

Mr. SCHEUER. With all respect, Doctor——

Dr. FLETCHER. Answering your questions, sir——

Mr. SCHEUER. Yes, let's get to the specific answers.

Dr. FLETCHER. I think we very likely should have, with all those alerting signals, put that kind of talent, because it was available——

Mr. SCHEUER. Well, I'm asking a simple question. I'm asking how much in the way of funding and how much in the way of personnel, scientific and technical personnel, was applied to develop specific answers to the problems of the failed O-ring that had appeared on a dozen or more launches, information about which was conveyed at least three times to NASA headquarters in Washington? What was the specific response to that in terms of funding to find the answers and application of scientific and technical personnel? How much? How many people? How many dollars?

Dr. FLETCHER. Well, if we don't have anybody here that can answer the question we can supply it for the record.

Mr. SCHEUER. Well, now, Dr. Fletcher, with respect, you weren't there and these people were there. Why don't we give them a chance to answer it?

Dr. FLETCHER. Right.

Mr. THOMPSON. Well, there was one of the four of us here.

Mr. ROE. Mr. Thomas, it looks like the bee is on you.

Mr. THOMAS. As I understand the question, sir, you are asking after the period in mid-1985 when the presentation was made to headquarters on the seriousness of the seal situation, how many resources were applied between then and January on trying to fix the seal?

Mr. SCHEUER. You had a big fat question mark that was articulated on three different occasions, warnings coming from Marshall to NASA Headquarters in Washington—in early 1983, in July 1985, and in August 1985—that described at least a dozen failures of the O-ring. Now, what did you apply in the way of resources, both in trained scientific and technical personnel and in dollars, to remediate that problem before the tragic launch 18 weeks ago?

Mr. THOMAS. I'm sorry, sir. I think we're going to have to present that for the record because the people who have to provide that are not in the room today.

Mr. SCHEUER. Well, Mr. Chairman, I would request that the people who have that information be requested to testify——

Mr. ROE. Well, in view—I think that the gentleman makes a very valid point. In view of the fact that we're going to break shortly, is there a possibility that you could contact some of your folks and maybe put something together for this afternoon?

Dr. FLETCHER. We'll do our best, Mr. Chairman, between the lunch hour.

Mr. SCHEUER. I would just like to make one more comment. Apparently there was a redesign task force on the O-rings at Morton Thiokol.

Admiral TRULY. Yes, sir; I understand there was.

Mr. SCHEUER. I want to know what they had in the way of funding and what they were able to put together in the way of trained manpower, scientific and technical manpower, to address this life-threatening problem of the O-rings and the joints between the three warnings culminating in July of 1985 and August of 1985, between that point in time and the time that this tragic launch took place. What kind of resources were made available to Morton Thiokol, either out of their own funding or out of separate—perhaps emergency—funding of some kind, discretionary funding of some kind, to remediate this problem? And I have to just pinpoint that, footnote that by saying that you really have achieved a notable knowledge base in the 6 weeks that you worked on the problem with insignificant resources. I don't know how you would quantify the cost to the American public of this tragic disaster. Leaving aside the acute pain that we've all suffered from the loss of those seven noble, great Americans, but just looking at it financially, as against the $5 million cost of preventing it, the *Challenger*—the hardware itself cost $3 billion or $4 billion, and if you crank into the computer the additional cost to the public and to NASA, the delay in the program, the upset, the loss of morale, all of these intangibles, you would probably come out to $5 billion or $6 billion. So you're talking about what would have been a cost benefit calculus of 1 to 1,000. If you had spent that $5 million before, you would have saved $5 billion afterward and, of course, those seven great lives.

So you can see the point that I'm getting to. Why didn't we spend this $5 million and why didn't we have these 200 scientific and technical people assigned to this problem after the ample and repeated warnings that NASA central headquarters had, up to and including July and August of 1985? What went wrong? What went wrong, and why didn't we make this remedial effort before the launch instead of having this excellent scientific attack on the problem that was perfectly self-evident before the launch after the tragic event, after the horse had fled the stable? And this is the information that I would like you to get us this afternoon.

Mr. ROE. All right. Well, we will defer that to this afternoon.

I'd like to put just one more technical question on the table before we break, again for continuity.

We mentioned, Mr. Thomas, relative to the burning of the NRB insulation from NASA's drawings, the insulation is in contact with the burning propellant. What evidence is there from previous flight exhaust gasses that the insulation burns? Is there any?

Mr. THOMAS. From the past static motor tests, I would presume there to be none. But from lab tests which we conducted during the investigation to determine the materials that were present in the joint, which one of those would burn and which one would produce black smoke, the NRB and the grease are the ones that produced black smoke.

Mr. ROE. So that's been ascertained since you've done your investigation?

Mr. THOMAS. Yes, sir.

Mr. ROE. OK.

The Chair now calls for a recess. We will return at 1:30, and may I suggest to members, please be here on time if you will, because we are going to begin immediately at 1:30, and we'll begin with Mr. Lee and your presentation at 1:30.

[Whereupon, at 12:20 p.m., the committee recessed, to reconvene at 1:30 p.m., the same day.]

AFTERNOON SESSION

Mr. ROE. The committee will reconvene, and as announced this morning by the Chair, our afternoon session will be devoted initially to a presentation by Mr. Jack Lee of NASA, followed up by Mr. Holloway of NASA and then Mr. Utsman from NASA, which brings then into clear focus the items and the areas of expertise and study that the different task forces have carried out in their review of the accident and other peripheral data.

Having said that, the Chair recognizes the distinguished gentleman, Mr. Jack Lee, from NASA.

Mr. LEE. Thank you, Mr. Chairman, and members of the committee.

Could I have the first Vu-Graph, please? The second?

With your permission, sir, I'd like to follow the agenda as displayed on the screen.

Mr. ROE. Well, wait until we get the lights out, somebody around here. And I think it would be helpful, Mr. Lee, if you would pull your microphone closer, please.

Mr. LEE. Yes, sir.

First, by introduction, I would like to give the organization which we used in accomplishing this effort, and the review schedule which we used during the process, then a little on the review approach for our team. And then I would like, by way of indicating the findings, I would like to present the significant findings of this team. We did not make recommendations; we came to the findings.

Next Vu-Graph, please.

The Commission members on our team were made up of Mr. Joe Sutter, who was the lead for the Commission; he is from the Boeing Aircraft Co.; Dr. Arthur Walker from Stanford University; Mr. Robert Rummel, who is now consulting and has been an executive with TWA; Dr. Gene Covert from MIT; and Mr. Al Wheelon from Hughes Aircraft.

Could I have the next Vu-Graph, please.

By the way, in way of support to me in supporting this team, I utilized primarily a small staff within the agency plus predominantly the project offices within the Marshall Center and the Johnson Space Center.

The contractor visits—by the way, the approach we took was to visit each of the contractors to accomplish our mission, plus a visit at the Marshall Space Flight Center and the Johnson Center. On the 5th of March we had an introductory session at Johnson, primarily to familiarize the Commission team with the overall requirements, the level 2 system requirements as imposed on the shuttle program, and how they are divided to be introduced into each of the elements of the shuttle, the elements being the orbiter, the external tank, the shuttle main engine, and the solid rocket boosters.

We started our contractor visits first with Thiokol and we were there on March 17 and 18. We were at Rocketdyne, the developer of the shuttle main engine, on April 2 and 3. We were at Rockwell on the 3d and 4th of April, primarily to discuss the orbiter; then at Marshall Space Flight Center, where we reviewed a number of specific questions that had been posed to us in advance by the Commission team members, and to review the solid rocket booster portion of the—the solid rocket booster, if you will. To distinguish between the solid rocket motor and the solid rocket booster, the motor is, per se, the propulsion system; the solid rocket booster includes the recovery system, the avionics, the thrust vector control system, and that sort.

On April 8 and 9 we visited the Martin Marietta Corp. near New Orleans, and that was for the external tank.

The review approach we took since we were primarily interested in looking at the production and development aspects—next slide, please—we were specifically looking at the production and development aspects of the shuttle in its entirety, as that effort relates to—could have been related to the accident. You have to recognize that we were performing this somewhat in parallel with the analysis effort, and it was not—the conclusions that Mr. Thomas presented earlier were not available to us at that time. We did this in parallel, so what we were looking at is specifically the concept or the approach to establishing design requirements, how these requirements were controlled, the review process, the certification of those requirements, the development and qualification—the development meaning component and subsystem testing as opposed to—and verifying design parameters, if you will, as opposed to qualification of an entire system to meet specifications. This also included the transportation mode, since the solid rocket motor segments are produced in Utah and they have to be transported across the country by rail to the launch site at the cape. Not only the transportation mode, but how this transportation mode was verified.

We looked into the design and production controls, the manufacturing aspects of these elements. In addition, we looked at the launch services, how the development contractor becomes involved with the launch activities, if you will, in overseeing his hardware and introducing requirements and ensuring that the tests and acceptance and checkout requirements at the cape, in fact, are met.

One of the areas that we knew that we were concerned about at the time we started in March was the critical items list. We reviewed the—CIL, by the way, is critical items list; FMEA is failure modes and effects analysis, and hazard analysis is, in fact, hazard analysis.

Our intent here was to understand and to recognize and to comment on, if necessary, the process through which these failure modes and effects analyses were generated, how they related to the identification of a critical item, and what category of critical item it was; and then, how that dealt with the hazard analysis.

The last item was in response to a number of specific questions that were, in fact, submitted to us in advance of the start of this process.

Could I have the next Vu-Graph, please.

We knew—we'll start now with the significant findings, and with the solid rocket motor in particular. These were findings that resulted from our review at the Thiokol Chemical Corp.—Wasatch.

We know, of course, by March that the solid rocket motor was pretty well implicated in the accident, and we were in fact aware of a lot of things that had gone on by that time, recognizing that failure analysis had been proceeding for about 2 months before this. So we were aware of the fact that the solid rocket motor was very much involved, so we did in fact—and we knew, by the way, that it was pretty well isolated; it could be isolated to the joint area. We thought that that was the case.

So by having that fact and recognizing that our charter to look into the design and development or production and development aspects of the solid rocket motor—we were more thorough in reviewing not only their whole process from the development standpoint, but specifically, we focused on the solid rocket motor joint. So we took as examples, to verify or to prove the approach to the development process, we took as examples how they dealt with the joint from a qualification/certification/verification standpoint. So we were, in fact, more specific in that area, as you might expect.

The significant findings with the solid rocket motor at Thiokol—the first one has to do with the subject we discussed this morning, and it has to do with the qualification of the motor. The qualification testing was not accomplished to the required specifications. And I gave you—I attempted to give you—an explanation of the process, from the requirements introduction by specification, the method, the areas that require certification, and the method to be utilized for that certification this morning.

Maybe if I can give one more example it will help clarify this thing.

In the—classically, the best thing we could do to ensure that that entire motor was qualified, completely qualified to all environments, would have been to encase it with an environmental chamber, if you will, taken it to the lowest possible temperature that had been established, and introduce as we fire the actual loads, lift-off loads, if you will. And that would then—if we accomplished that full-scale testing, that would in fact have qualified-tested the entire motor, including the joint.

Now, the way we did this, because we didn't have an environmental chamber and we did not determine it to be necessary to have an environmental chamber, we qualified the motor to the environments that were available to us. And by the way, this did range from some 40 degrees to close to 90 degrees, so we were in the area of most concern; that is, the mean-bulk temperature requirements. We did—in that same logic, in order to be able to certify that the joints did meet the requirements, we chose to do that by analysis, and I explained that this morning. We chose to perform that analysis, and in that analysis we used the specification for the O-ring, which does specify it can be used from a range of minus 30 degrees Fahrenheit to 500 degrees.

Now, the reason that issue was brought up is that in today's environment, the thing was not qualified-tested to that full range, as I explained. And based on the interpretation of the specification by

Morton Thiokol, enough effort, I would say, did not go into completing this complete verification by analysis. And again, in hindsight, you would say that our selection process—and that would be NASA's involvement here, too—the selection process for that analysis was somewhat inadequate.

The next point is the adequacy of the O-ring process and quality control. Now, we did not find in our investigation, nor did Mr. Thomas find in his analysis investigation, that the O-rings used in this flight were in fact not acceptable or were not of good quality control, nor that they were not properly processed. But in our reviewing in detail this process, we found it had not been identified as a critical process, which we believed it should, and there were a number of things and areas that we believe could be changed to give a better assurance that in the future that O-ring did, in fact, get processed properly and that there was no way that you could have a quality escape, if you will. And again, I would like to remind you that we did not find anyplace where we had an improperly processed O-ring; but the process itself—and we felt we had that charter to look to that—and so we did, in fact, believe—or I'm not sure that's the particular recommendation that came out, but we did feel strongly that that process should be beefed up.

The next point, it is questionable whether the horizontal hot fire testing compromises flight simulation. Now, we knew of this possible concern on the part of Mr. Sutter's team, so we had started—a month or so ago—a pretty detailed evaluation of the merit or requirements, if you will, first of whether the solid rocket motors should be fired in the vertical or the horizontal; and in doing so, we are assessing facilities available around the country. We are looking at the requirements which we are trying to impose on ourselves to ensure that the motor is properly qualified, and we are weighting these to determine which we believe would be the proper route to go. Once we complete this, we will make this information available to Admiral Truly who, in turn, will make a decision on that part of the future testing of the solid rocket motor.

The next item is in somewhat the same category, but it's a little different. There's a difference—there was, in fact, a potential difference between the certification testing and the flight configuration. And specifically, what happened here is when the motor is installed in the vertical, there is some adjustments, or changes, if you will, in the famous putty configuration. It tends to not assume the same shape necessarily that it would when the vehicle is stacked in the vertical. And by this, we mean that when we're ready to static test the motor, it would not be in the same configuration we assumed it would be in the vertical. So there was some adjustments, if you will, some tamping of the putty, some fixing of the configuration which we believe could, in fact, make a difference in the results of the static test.

The fourth item is in case reuse. Now, we did not find this only with this production and development team; we had the benefit of some of Mr. Thomas' earlier analyses. And the situation which exists here is, by going back to remeasuring cases which had been reused—now, these are the solid rocket motor cases; you remember that once we fire these, we bring the solid rocket motor back in, and as part of the refurbishment we clean the motors out and we recast, if you will, the propellant. We found, in measuring some of these reused cases, that the dimensions had changed. Now, this was somewhat of a surprise to us because it was not anticipated or understood that this should have happened during the reuse. Our understanding of the characteristics of the material, the way it was processed, should not have allowed this change in dimension.

Now, let me quickly say that in Mr. Thomas' analysis and our understanding of this dimensional change, there is no indication that the reuse of the—the possible growth of cases due to reuse had an effect on 51-L, but it was characteristic of the change in the cases and it's something that was of surprise to us or change to us, and we recognized that we had to make the determination.

We think we understand this and it is being properly analyzed now, and I have no doubt that we will solve that problem of the lack of understanding of case reuse.

The next point is inadequate understanding of the field joint operation as designed. We came to pretty much the same conclusion that Mr. Thomas' analysis team arrived at, and he did this through additional testing and analysis and development testing, if you will. We came to that conclusion by just assessing the design and the process and the understanding as the design was—as the joint was designed and tested.

The last item is the case configuration changes resulting from transportation in the horizontal. Because of the length of these cases where they are cast, we transport them across country in the horizontal position. As they are—they stay in the horizontal for long periods of time. The case tends to become oval. Now, we think that this is a potential contributor, this becoming oval, when it gets to the cape to the possible out of roundness. Now, we have seen in the Commission's report, this is addressed where there is some consideration for that—for either fixing the transportation mode or being able to properly assure that the roundness is in fact adequate or correct prior to stacking.

May I have the next one, please?

The next area is that for the shuttle main engine, and these are the significant findings we arrived at from our review at Rocketdyne. We found that the engine itself is a high-technology, high-power density state-of-the-art engine, a very, very precision instrument. We found that because of this, and because of the long relationship, I guess, in working with the liquid propulsion engines at the Marshall Space Flight Center, our people at NASA and those of the contractor had a very good understanding of not only the programmatic, but of the technical requirements.

The third item was a consideration for margins of critical components that were not demonstrated by test. Now, this does not have to do with the acceptability or the certification for flight. Our concern here is, over the long reuse of the engine, we believe that we are going to have to develop or introduce some test that will allow us, by actual test results, to recognize the margins that are in some of these components. The way we do it today is, we test around the nominal, and we analyze or compute what we think those margins are. We believe that we're going to have to extend our test program in the margin area to be able to recognize these margins; as such, we will understand the performance of the engine better as it relates to performance over the long period of time, the possible reuse, the overhaul, the refurbishment of the engines themselves.

Could I have the next one, please?

At Rockwell, on the orbiter, we also found that there was a very good understanding of the programmatic and technical requirements between NASA and Rockwell. We also found that Rockwell had some concern relative to the level of involvement that they had with the orbiter as it is processed and turned around, if you will, at KSC. And the emphasis here was more of involvement in that process in a way that their technical knowledge, their background, their corporate memory from a technical standpoint of the orbiter could best be brought to bear on any potential problems or foreseeable problems on the orbiter itself.

The next item was the number of the critical components, and I've listed two because they've been used before, the 17-inch disconnect and the brakes, and there was a list of these—a number of components within the orbiter; and this, by the way, is not only in the orbiter. There are some others in the SSME; there are some in the external tank, and I'm sure there are some others in the SRB, which we will ferret out. But in particular, there are a number of critical components like these that require some reassessment. This activity has already started; in fact, it had started before the accident.

The last one has to do, again, with a concern on the part of Rockwell that the critical payloads like the Centaur, which are relative hazards because they are, in fact, cryogen propellants within the orbiter bay, possibly were not receiving as much of an overall safety system assessment as you look at the orbiter in totality with the payload attached, and in order to be able to assure that all safety aspects were covered. These, by the way—in fact, all of these findings are being—actions are being taken by the Orbiter Project Office at JSC to start effort on these.

Could I have the next one, please?

The last one is the external tank. We also found there is a very good understanding by both NASA and Martin on program and technical requirements. Martin had some concern, not quite to the degree of Rockwell, that they didn't have quite the direct involvement at KSC on their hardware, if you will—and "their hardware" meaning the development contractor's hardware—they did not have the same involvement or adequate involvement that made them feel comfortable that everything that happened to that hardware, in fact, was getting the proper assessment, again based on their knowledge through the years of development qualification. There was no problem, by the way, identified by the Martin people, though.

And then the last item has to do with the range safety destruct system. Today we have the range safety destruct system on both SRB's—or both SRM's—and the external tank. And it has been—this has been a question that has come up over the years, and we are in the process of working with those people who established that requirement. If we can safely—or within the bounds or within the requirements established—if we can eliminate a destruct system, if you will, from the external tank, we'd all feel more comfortable about that.

That concludes the significant findings. I would like to summarize one point. We did not find, in any of our reviews with these contractors, a real deficiency in the basic processing of establishing and identification of requirements, how those requirements are introduced by contract, how the specification identifies those, the requirements for certification and verification, configuration control, acceptance. We found that the procedures, if you will, the mechanism for being able to accomplish the production and development programs of all these vehicles were, in fact, sound and only in some areas where that has appeared to break down, particularly in the case of the qualification testing—and I won't say that exactly broke down; there was some misunderstanding, and possibly, in light of today's environment, we should have put more emphasis on the certification aspects of that seal—but the procedures and the implementation of these procedures seemed to be sound throughout all the contractors.

Mr. ROE. I thank the gentleman, and I would like to welcome Mr. Thomas Holloway of NASA's mission planning and operations team. We welcome you, Mr. Holloway; go ahead with your presentation, please.

Mr. HOLLOWAY. Mr. Chairman, thank you.

First chart, please; second chart, please.

I am reporting on the mission planning and operations team, and first I'll introduce the members of the Presidential panel of the same title. Dr. Ride was the leader of that group; Mr. Rummel participated; Mr. Hotz, and Mr. Acheson.

Next chart, please.

First, let me characterize what our group did, the Mission Planning and Operations Panel. There was not a focus for our group because there was not any obvious relationship to the accident itself, so we were in the process of looking at a large number of activities that go on in the process of preparing for and executing the flight operations during a shuttle mission. And as such, we established a fairly large group of individuals to go off and examine multiple areas in flight operations to see if, one, we could find anything that contributed to the accident; and second, if we saw any indicators in those functions and activities that needed attention to prevent future accidents.

First, I will say that I will not discuss each one of these things in detail today because I don't think they are important for your purpose here, but I would like to characterize generally what we did find.

First of all, we did not find any concerns that were a total surprise to the system and to the people involved. I would characterize what we did find in three ways. First, there were many of the areas that we examined that we found that all was proceeding very well for the medium-to high-fly rate that we were looking toward, and the procedures and processes were working very well.

Second, we found situations where the functions and activities may not have been what we would have liked for them to be for a medium- and high-fly rate, but the procedures and plans and budgets were in place that would allow that to evolve to more than a satisfactory situation.

And the third area were areas of concern that perhaps require some emphasis on the part of the program as we go forward to ensure that evolves properly, to ensure that we have everything in place that we'd like to have.

Next chart, please.

I might add that the dominant portion of the activities we looked into fell in the second category.

We met with the Presidential Commission 11 times, presented 22 formal briefings and numerous data packages and formal reports. That amount of time spent with that group was on the order of 65 to 70 hours in technical briefings, and some 320 to 350 people at one time or another participated in the generation and the presentation of that information.

Starting at the top, we discussed that group the 51-L mission preparation, including the crew training, the crew activity planning, the trajectory design, the ascent abort modes, and how that worked out on 51-L. We also talked about payload, our cargo manifesting, and providing opportunity for the SR&QA people to be interviewed on March 12.

March 20, we had our joint session to put together plans and schedules. On March 24, we discussed the range safety history that Mr. Lee has previously discussed briefly with you; the history of that program, how it evolved on the shuttle itself; what the current procedures are; what the flight rules are that control its utilization, and where we are today.

We discussed the milestone history; in other words, how well we had been doing with schedules in terms of mission preparation, and how we anticipated we would be able to perform in 1986, had that flight schedule been allowed to evolve.

We reviewed our weather flight rules; RTLS rain damage assessment; and again, on March 25, we provided information on shuttle main engine failure containment, and an opportunity for the Commission members to interview some safety, reliability, and quality assurance personnel.

On March 31 we reviewed orbiter testing, what we thought that the operating base was for the flight operations group; payload safety; crew training, and the state of our crew procedures program that maintains flight crew procedures.

On April 7 we participated in a meeting at Marshall, again to allow the Commission to interview some SR&QA personnel at that location.

On April 8, we reviewed workload assessment, how much overtime and how the annual leave was being used and so on and so forth, particularly for the Mission Control Center personnel in Houston. We reviewed the state of the orbiter software program and how we develop software and test it and prepare for each flight. We reviewed the cargo manifesting, the process and procedures associated with putting a cargo together, and the history of how well that's gone and how many times we have changed those cargoes and those payloads as a function of each flight.

On April 9, in a 9-hour meeting, we reviewed the landing considerations, KSC landing considerations relative to rain and brakes and nosewheel steering, and also transatlantic abort landing considerations of the same nature.

On April 14, we reviewed the ascent envelope expansion, or the state of the ascent envelope in terms of flight design and trajectory, and spent the afternoon reviewing the history of the first stage abort options from RFP days up through 1983.

On April 15, we provided an opportunity for the Commission to continue their review on safety, reliability, and quality assurance.

Next chart, please.

On April 18, we submitted to Admiral Truly our report; it was later submitted to the Commission by Admiral Truly's office. I won't review those in detail, but it included all those things I've previously discussed.

Now I'd like to review the major findings of the group. Before I do that, I need to tell you that they are not all related subjects, so they don't flow very well. They are all individual subjects, or most of them are individual subjects, and as such they don't have continuity, one from the other.

First, under mission planning and preparations, the 51-L mission manifesting, mission operations, flight crew preparations, prelaunch, and launch were typical and satisfactory and had no effect on the accident. Furthermore, the flight crew and the ground crew were well trained; they had fulfilled all of the training requirements and, more importantly, we all believe that the crew, both ground and flight crew, were indeed well trained and well qualified to fly the mission that would have occurred had the accident not happened.

Under 51-L mission preparation, first, there were no actions possible that could have resulted in the survival of the 51-L crew. As has been stated before, during first stage the SRB's simply must work. There's no possible procedure that can allow us to separate from a thrusting SRB with the current configuration that would allow survival of the orbiter.

Second, the range safety system that Mr. Lee previously discussed did not contribute to the accident, and the actions of the range safety officer were important. As you remember, the range safety officer destroyed the SRB's in flight, and he had the proper—he took the proper action based on the conditions of the day in the situation that he had on his hands at that particular time.

Also, we have initiated a joint NASA/DOD review of the range safety system, and we will be reviewing those issues, many issues, in that system, including the one that Mr. Lee discussed earlier today.

Under NSTS mission planning, we found that the operations maintenance inspection program—that's the program in which the requirements to inspect and maintain the orbiter from structural equipment to line-replaceable units, and the process of getting those requirements introduced into procedures at KSC that the technicians can execute, including a methodology that allows the feedback to the appropriate people in terms of accomplishment of those procedures—were immature and did not provide what we would like to have in the future to make sure that all the requirements are met and, in such cases when waivers are entertained, that they are identified very early in the process and can be dealt with at the technical level in time to make timely decisions. That work has been in progress for a year or so at this time, and we expect that it will evolve satisfactorily in the future. So it's a matter of emphasis in completing the work that was in progress at the time of the accident.

Under NSTS mission operations, one of the major findings was that the current program commitments precluded devoting adequate resources to developing a capability to support the increasing flight rate. And what I mean by that is, that either because we were more interested in flying the flights or because the flight rate demanded all of our attention, we were spending all of our resources toward flying—a majority of our resources, at least—toward flying the flights rather than looking toward the future flight rate and the requirements that it would take to develop the flight products and the procedures and the details to fly at the higher flight rate.

Additionally, at the time of the 51-L launch, KSC landings—one of the favorite subjects that's been discussed by many people—did not constitute an unreasonable safety of flight risk based on known failures.

Next, statistical weather and forecasting uncertainties have resulted in several wave-offs from KSC and dictate a need for multiple landing sites for end-of-mission. We will always need multiple places to land the shuttle regardless of what the planned landing site is, and we ought to put those in place and have plans in place to utilize them and turn the vehicle around and prepare for the next flight.

The current—the next item speaks to the current landing and deceleration systems, which have not demonstrated an adequate margin for routine KSC and transatlantic abort landings. We believe that for a long-term program we need a better landing and deceleration system; and, in fact, the program has in place many of the elements of what we believe are required to cause that to happen.

Crew escape systems—we reviewed the history of the crew escape systems from the inception of the RFP back in the early 1970's through 1983, and there are very many varieties of crew escape, including augmenting the basic shuttle to allow it to perform a recovery-type operation and allow it to land on a runway, from ejection seats to escape pods, to situations where a group of crewmen might bail out of an opening in the cabin during glided flight before impact. During that review, we found that these systems were all reviewed numerous times throughout the history of the shuttle program; and because of what at that time was considered to be limited utility—and what I mean by that is that the systems that were envisioned to be put in place would not cover an adequate number of the envisioned scenarios that might happen, such as 51-L—it was not found to be a usable system; the technical complexity; the ability to build such a system and ability to monitor the impending failures and execute the escape system in time to make it useful; and cost and schedule and performance impacts, performance impacts being primarily payload-to-orbit—no system was implemented.

Last in this group, we reviewed the astronaut office involvement in the program and found that they play a significant role in all activities associated with the development, flight preparation, and flight execution, and they and their management are members of all major decisionmaking boards and panels.

Under flight rate and scheduling, we found that the 1985 mission operations were successful in spite of significant remanifesting perturbations. We did take on a number of challenges in 1985 outside of the scheduled manifest; we had a number of upsets, one including an engine shut-down on the pad; we remanifested the cargo and flew a new mixed set in a matter of 6 or 8 weeks. We took on the challenge of flying the 51–L mission and rescuing the Navy Syncom satellite in about 4 months, and executed that and, in my opinion, did all of that quite well.

However, the trends indicated that the milestones required to support the preparation for the 1986 flight schedule would have been extremely difficult. We may have arrived at the point where our schedules did not meet our capabilities.

We had four major conclusions that coincided with those 11 major findings.

First, we believe the NSTS program should develop a bottoms-up strategy for expanding our flight rate. And as a start, rigid manifesting criteria need to be established and enforced.

Also, we believe that an inspection and maintenance program should be implemented that will ensure that we get the job done as long as the shuttle flies, and work is in progress to make that happen.

Third, the NSTS program should focus attention on defining and providing an adequate margin for end-of-mission and intact abort landings, and that work is in progress and it includes both ground facilities and flight hardware.

And last, the program should evaluate the options and utility of providing crew escape systems and augmenting orbiter abort modes using the technology of 1986 with the understanding of the program as we know it today.

Mr. Roe. I thank you, Mr. Holloway.

Now we'll hear from Mr. Utsman, who is the final witness on the Pre-Launch Activities Team. Mr. Utsman.

Mr. Utsman. Thank you, Mr. Chairman.

The first chart, please. Next chart, please.

This chart depicts the organization that we used in order to carry out the task of supporting the prelaunch team of the Commission.

The prelaunch team's job was essentially in three areas. One was to look at the NSTS processing that had been done for 51–L; the second part was to look at the flight readiness processes that led up to the launch decision, and the third area was to look at the security aspect and determine if there were any problems in that area.

In carrying out those three tasks, we organized into three teams, as shown on that chart.

I would like to say that the purpose was always to support the Commission's activities, looking for causes of 51–L problems since this activity was primarily started immediately after the accident, but we also realized that due to the comprehensiveness of the review that there would be many lessons learned and many things that we could find that may not be associated with the accident and we wanted to capture those so that we could use those and make improvements on those. So that was always in our minds.

Next chart, please.

We felt the review was comprehensive. It involved about 900 of our people. It involved all levels of——

Mr. ROE. Is it 900 people just—I hate to interrupt you, but is it 900 people en toto or just for your area of review?

Mr. UTSMAN. It was in this area of review.

Mr. ROE. I thank the gentleman.

Mr. UTSMAN. It involved all levels. We had from engineering management all the way down through technicians; we wanted to have technicians involved for their viewpoints. We had all the disciplines involved. It did involve our NASA people and our contractor people, and the 900 did include both NASA, Civil Service, and the contractor. We had participation with some members of the Air Force, and we had an active participation by members of the flight crew, which was important to us.

In conclusion, we had several significant, relevant findings which we'll discuss in a few moments. We did find that our operating procedures do require correction in some areas in that there are some processing practices which can be improved. We document the results, and it was in a large amount of volumes due to the amount of work and review that went on. What we tried to do to simplify that was to summarize it into a single document that would capture the essence of those other documents, the 6,000 pages, and that was submitted to the Commission along with a copy of all the background material which was used.

Next chart, please.

I'm going to move into the first area, the NSTS processing review.

The job there, right after the accident, we impounded all the data, which included all the paper, any data that was associated with the 51-L processing. And what we did then was formulate into teams—which I'll show you in just a minute—and went into the process of reviewing every bit of that documentation in the records, as well as interviews, to ascertain whether we had had any problems associated with any of these activities. We looked at how the flight hardware met with our mobile launch platform; we looked at pad B, our launch complex pad B, since this was the first use of it, to look for—if there were latent defects that could have been in our processing or in bringing that activation on board; we looked at the GSE that interfaced with the vehicle and the facilities that interfaced with the vehicle, looking for anomalies.

We reviewed all our payload processing. We looked at the ICE team. We, along with DOD, did look at the range support that does support the activity, prelaunch, at KSC, and analyzed all our problems and documented these findings.

Next chart, please.

These are the teams that we did put together that did support this activity. As I mentioned, these started early on; and when the task force was formed, we went back and did a quick check to make sure that we did have a degree of independence. We didn't want to have people reviewing their own work, but we wanted people who were familiar with the work to be able to review it, and we found that to be the case.

The outside members working with us, such as the flight crew members as well as the staff from the Commission, gave us the feeling that we had a degree of independence since we recognized that these were mainly KSC people looking at KSC work. And so we felt comfortable that that was the case; we did have an objective look.

Now I'll go into the major findings concerning the processing. Next chart, please.

Our first major finding was that, in conjunction with what had gone on on the accident analysis team, we in looking at our activities could find nothing that led up to or contributed to the 51–L accident.

Now, I'd like to hesitate and stop there. There is one, in the area of the SRB joint—the way the joint is put together, it is what we call a "blind mate;" that is, you can't see the internals once you're done with it. We do know that you can put the joint together correctly. We know this from tests, and that you can have some joint sealing degradation; and the type of things that you can have, even though you have tested it and put it together properly, is that you can find some minor, small contamination—for example, when a pin goes in, as you saw in the earlier joint, there may be a metal sliver in there in that, and there's no way to tell it. The O-ring could be damaged but yet still pass the seal test under some extreme conditions. And we know that we can have water in the joint, and we have no way to test for the water in the joint, as has been attested.

When it was looked, it weighed—even though the processing was done properly, as Mr. Thomas said earlier, it was felt that there was any low probability that there was any problem associated with the—contributed by the processing.

Next chart, please.

One of the problems that we did find was that our work control documentation system does require revision. This system has been in place and is a derivative of the system that was installed and instituted in early manned flight. What has happened to it is that, due to the activity, it has become cumbersome; and, to use a term, it's not very user-friendly. This led to two problems. One was that people became sloppy in their practices, and this is an area that you can often say is just a discipline problem among our people. When we looked at it we found that we had given them what we thought was a task and a system that was too cumbersome to really work with effectively, so what we're doing right now, we are in the process of looking at it. We have several teams bringing in all levels of the workforce, looking at how we can streamline it and make it what we would call more user-friendly. We are also going to be emphasizing on the importance of the system as well as how to use it, and we think that those will lead to an improved system with more rigor in it and more discipline.

We did not have a problem at the time with the paper system, assuring that there were no contributors to the accident, because with the effort we put into it we could find where the records were inadequate by talking with people and working in that manner;

with special analysis, we knew that we were all right. This is not what you want for a normal operation, and we intend to correct it.

Next chart.

Launch complex 39-B requires additional modification. This wasn't really a surprise to us; in fact, the complex turned out to be what we consider very good. However, we know we've got some hardening modifications to be made, and these are just where, in some cases, panels bulged due to negative pressure that we hadn't anticipated. We're going to have to put plugs and things like that; it's not a major item.

The major thing we did find was that this freeze plan that we had instituted this time, which was also the first time it had been used, was inadequate, and that led to the significant amounts of ice on the launch complex. This is going to be corrected, and it's underway right now, the definition of its correction.

Next chart, please.

One of the findings when you went through with the 900 people was that there were cases where we had had some inefficiencies in our processing due to high workload. The high workload contributed to a peaking of work that was somewhat more than we had anticipated. The four orbiters being processed was a new time for us, and when we got into it, it is not something—due to the short-term nature of what we saw of the problem—that you could add people. I might say that in most of our cases, to get people fully up to qualification requires some 18 to 24 months, so you can't just go out and hire people, bring them in, and then have them be able to get the job done.

So what we're looking at now is, very carefully, how we can approach our shifting and our manpower mix, along with our contractors, to assure that we have as much flexibility to unforeseen problems as we can in the future.

Mr. ROE. For clarity, will the gentleman hold at that point?

On the top of that chart, you're referring to manpower limitations due to high workload-created scheduling difficulties. You're speaking now to the launching process itself?

Mr. UTSMAN. That's correct, sir.

Mr. ROE. Thank you.

Mr. UTSMAN. Next chart, please.

We did find a few test team errors that were caused by not following established procedures. Most of them were related to work control documentation systems as we discussed earlier, the lack of being user-friendly; however, we did have a couple of very serious cases. The most serious one was that we had an undetected slamming of the 17-inch disconnect. We know it's a critical problem. The reason it occurred—well, there were many reasons, but the fellow who did the—who slammed it is an experienced person who took the judgment onto himself that this was not a problem since he had seen it before and understood the background. Our system is such that if you do something that is out the ordinary, you should document it, and this was not documented so therefore it went undetected through the system. There was no indication of a problem. It was reported during the post-review of the data, but again, it was a very serious—in our view—situation of not following established procedures.

What we're doing is obviously—I think the seriousness of that is being stressed throughout the work force. We're also going in to look at situations where—have we been as rigorous in ferreting out places where human errors can occur on critical hardware, and see if there aren't ways that we can preclude those? We feel, with that, that we're going to reduce the propensity for this type of situation.

Next chart, please.

Mr. Holloway reported that the test requirements system required revision from their view of it. This is a similar type of finding that our team had, looking at it from a KSC processing standpoint. Between the people in the program, there is work underway right now to make the correction to both of these findings.

Next chart, please.

The orbiter logistics system supporting 51-L was found to be inadequate, causing significant LRU cannibalization. I think this has been well-reported. It was created by just a lack of parts and the level of degree of activity. And we ended up, out of some 300 parts required for the processing of 51-L, that 45 of them had to be removed from another vehicle and placed into *Challenger* for use in 51-L.

Besides the manpower implications of that, there is an implication that you just don't like to be working on vehicles because any time you get into a vehicle, it creates a potential safety hazard.

The program has been working—Admiral Truly has initiated action already to try to beef up the spares program.

Next chart.

Additional analysis will be required to assess environmental effects upon launch capability.

From the ground systems standpoint, we had not developed adequate modeling, in my view, to know comprehensively all the problems that we might have through the launch complex. We had one cylinder, for example, that reacted slower. We had qualified it to 32 degrees, but when we looked at it, even though the ambient temperature was above 32 degrees, we hadn't run the modeling to find out exactly the temperatures there, and it was below freezing and it reacted slower. It didn't create a problem, but it meant—it was an area where we need to improve our information.

Also, the instrumentation and analysis of the temperatures all over the launch complex, we feel, is going to have to be improved in that, as has been pointed out, you just can't take a temperature measurement at one spot and have that be representative of the total complex. So we're looking at modeling techniques so that we can have an improved assessment, really.

Ice debris was greater than predicted. There was much discussion on the prelaunch activity about the ice debris and where it would go. We did review that and we found that when you reviewed the films postlaunch, that the aspiration effects were greater than had been anticipated by the people who, prelaunch, had participated in that discussion.

There was—again, the ice did not create a problem, but it did show us that there is a need for improved modeling—if not for ice, to look at the aspiration effects as it may affect all debris. So this is an area of reassessment.

Next chart, please.

That was the final finding that we had that summarized all the 10 teams' activities as far as the STS processing. At this point I would move into the flight readiness review process as it led to the launch decision.

The way we handled that, due to the nature of it, it was one where I think, in all fairness, the Commission took the larger lead and we worked off of data, somewhat, that the Commission had provided us.

What we did, we analyzed the policies and procedures and found that essentially we were in compliance with them.

Next chart, please.

That was our first finding; and again, as has been stated several times, the process itself—the structure of the process—is a consistent, fair process.

Next chart, please.

However, in all honesty, the flight readiness process did not address the critical SRB flight safety issues. And part of the rationale that you get, I think, in our determination it was the lack of understanding of the full certification process. So therefore, when it came forward—even though the indications were coming forward—when it came down to the launch decision, there was not a clear understanding of the mechanism that was going on in operating at the low temperatures in the joint. And so consequently, we've got to review our whole system and how we lead up to that and decide what action should be taken.

Next chart, please.

This is another area that, I think, has been well documented. The communication during the launch decision process was inadequate, and that may be a poor choice of words on my part. What I was trying to portray is, it was obvious in the after-effect that there were people in Morton Thiokol at the engineering level whose concerns didn't reach those who said that if they had known of them, they might have taken other actions. I don't know, other than that says that there has to be something wrong in the communication there, for improvements.

Also, with regard to the ice debris and Rockwell, we had the senior officials of Rockwell believing they were talking on a flight safety issue, while the senior officials of NASA believed they were talking about an issue that was not safety of flight, but a refurbishment issue. And again, that type of communications indicates there was a problem with the communication.

Next chart, please.

That was all I had on launch decision, in that there is a lot of review in that whole activity. But that is all that we were asked to look at as the prelaunch team.

The final area we have is the prelaunch security. In that activity, the assessment, again, was initiated right after launch, and the review was done in conjunction not only with KSC, but aspects of local, State, and Federal agencies to assure that all aspects of the security problem were looked at. And the next chart documents our major finding, in that there were no factors contributing to the 51-L mishap that were found as part of the security assessment.

Next chart, please.

However, we did say that based upon our look-see, or looking at that whole activity, that we wanted to reassess our national resource protection to assure, in light of all that we looked at, that we were doing a proper job, and this type of review is ongoing.

And that's all I had, and that was the end of our findings, sir.

Mr. ROE. Thank you, Mr. Utsman, and your other colleagues for an excellent presentation and one of candor. And without objection, the Chair would move that testimony, the written testimony accompanying the charts and graphics, be incorporated as part of the committee's records at this point in the record. No objection; so ordered.

[Materials to be supplied.] [See Appendix 2 p. 662.]

Mr. ROE. In the preagreed discussion we had this morning as to our process this afternoon, Mr. Scheuer, the distinguished gentleman from New York, was proceeding upon a particular course of questioning, and we decided it would be apropos and workable to finish the testimony first of the distinguished representatives of NASA, which we have done at this point, and therefore the Chair now defers to the gentleman from New York, Mr. Scheuer.

Mr. SCHEUER. Thank you very much, Mr. Chairman.

Dr. Fletcher, we were discussing this morning the remarkable body of evidence, the remarkable data base that NASA achieved in a comparatively short period of about 6 weeks after the tragic accident by the application of approximately $5 million and approximately 200 scientific and technical people.

And I asked you if you could get for us this afternoon the resources and the personnel that were applied to addressing the problems that were enumerated in the February 1983 warning, the July 1985 warning, the August 1985, warning, before launch.

Dr. FLETCHER. Mr. Scheuer, as you know, we did look at that very hard during the lunch period, and I think we have some answers for you.

Mr. SCHEUER. Good.

Dr. FLETCHER. There was a study started after a flight readiness review when the joint problems were discussed quite extensively. The study was started in early 1984, and it looked at things like margin assessments, new designs, and new materials to be used in the joint. Additionally to that, at the Marshall Space Flight Center, there was some internal Marshall effort that looked at modelling of the joint, things like putty layup, et cetera, that was ongoing. And also, after each mission, when an incident occurred with the joint, there was some manpower and some dollars associated with doing a postflight analysis.

The total of this, with the information that I could gather over the lunch hour, was approximately $3.5 to $3.8 million. I don't know exactly how many people were involved, but I can supply that for the record.

[Material to be supplied follows:]

Material Requested for the Record on Page 126, Line 2088, By Mr. Scheuer on June 12, 1986.

Approximately 40 MTI and MSFC engineers were involved in the early redesign assessment during the months preceding the accident. The initial studies, in early 1984, utilized approximately 17 engineers. Additional personnel were added as needed for putty lay-out, subscale testing and other structural and mechanical analyses.

Mr. SCHEUER. Over how long a period of time did this effort take place?

Dr. FLETCHER. This was over a period of about 2 years.

Mr. SCHEUER. Starting when?

Dr. FLETCHER. In early 1984.

One thing that I have not been able to quantify that I think is worth pointing out is that the—because the problem had been recognized earlier—but as the Commission's investigation quite clearly shows, we did not deal with it to the extent that we should—we did institute a design change into the joint, the metal for the joint itself, which has been referred to as a capture tang, that was designed to reduce the joint rotation that has been discussed here today. That capture tang, that metal in that captured tang was designed into the design for the filament-wound case; that's a new version of the solid rocket motor that is designed and is under development to be used out at Vandenberg Air Force Base for west coast launches. And in the summer of last year, the decision was made——

Mr. SCHEUER. The summer of 1985?

Dr. FLETCHER. The summer of 1985, yes, sir.

The decision was made, in the case billets, the raw billets that were being produced to later be machined, that enough metal would be—the design of those raw billets would have enough metal so that the steel cases could also have such a capture tang.

I don't have a dollar number to put on what went into that particular design change, so I guess I would, in summary to answer your question, it was less than $5 million; $3.5 to $3.7 million over a period of the last 2 years, plus the cost of that capture tang, and I can get that. But I don't have it now.

Mr. SCHEUER. Well, now, as of August of last summer, in the third of these three early warning signals that all was not well, the recommendation was made in this final briefing to the NASA people, through Michael Weeks and others, the recommendation was made that efforts need to be continued at an accelerated pace to eliminate seal erosion, and that additional tests needed to be conducted for establishing margins of safety for eroded O-rings.

Now, this was 1½ years into that 2-year effort that you're talking about, so apparently it was quite clear as of 18 months into that period that there was vast additional data that had to be accrued before launch could be effective.

Let me ask you, do you agree with the statement made in this Presidential Commission report, on page 148, that—I refer to item 5 in the second column—"The O-ring erosion history presented to Level I at NASA Headquarters in August, 1985"—the briefing that I just referred to—"was sufficiently detailed to require corrective action prior to the next flight." Do you agree with that?

Dr. FLETCHER. I accept that. I'm sure that it is correct; it was a conclusion of the Commission. I think it is quite clear, in hindsight, that the O-ring problem should have been dealt properly with, and that's a point that you made earlier and I'm very glad that you did—is that the fact that this problem was missed was not only a problem at the Marshall Space Flight Center, but also at NASA Headquarters. The signs were there; the Commission—in retrospect, the Commission and our task force and this tremendous amount of effort that we've put on it, which is the nature of accident investigations, has shown that improper attention to this crucial problem was given, and it was not limited to the people at the Marshall Space Flight Center.

Mr. SCHEUER. Mr. Chairman, we have in the audience, the Deputy Associate Administrator of Flight for NASA, Mr. Weeks, and I wonder if we could ask him to come to the witness table.

Mr. ROE. I believe Mr. Weeks is here. If we may, Dr. Fletcher, we'd like to have him come to the table for some questioning.

Dr. FLETCHER. Mr. Chairman, this is Mr. Michael Weeks. He was the Deputy Administrator at the time of the accident.

Mr. SCHEUER. Deputy Administrator for Flight?

Dr. FLETCHER. I'm sorry—Deputy Associate Administrator (Technical) for Office of Space Flight—or for the STS.

Mr. ROE. Mr. Weeks. Go ahead, Mr. Scheuer.

Mr. SCHEUER. Mr. Weeks, in February 1983 you signed a waiver of the fail-safe requirement for the joints, correct?

Mr. WEEKS. That's correct.

Mr. SCHEUER. Right. And then in July 1985, you were alerted to the problem of the joints when Irving Davids wrote a memo, which you were copied, right?

Mr. WEEKS. That's correct.

Mr. SCHEUER. OK. Then in August 1985, you were present at a briefing about the repeated failure of the O-rings in which you were urged—you, I mean the collective group—were urged to make efforts to continue at an accelerated pace, efforts to eliminate this seal erosion, and to conduct additional tests for establishing a margin of safety for O-rings, OK? Right?

Mr. WEEKS. Yes.

Mr. SCHEUER. Now, what I'd like to know, at that point in time in August 1985, with a launch date set for *Challenger* staring you in the face not many months hence but with these critical warnings in your possession, what kind of resources did you spend to address yourself to the problems that this memo urged you to address at an accelerated pace? How many people? How many dollars? What did you learn, and what did you do about it?

Mr. WEEKS. As Admiral Truly spoke to you, I think I should——

Mr. SCHEUER. Mr. Weeks, I'm asking you a couple of very simple questions——

Mr. WEEKS. I understand that.

Mr. SCHEUER [continuing]. Which demand a factual answer.

Mr. WEEKS. The effort after that August meeting that we had, which was quite an important one——

Mr. SCHEUER. What was important? The meeting or the effort?

Mr. WEEKS. No, the effort and the problem of the erosion of the secondary O-ring——

Mr. SCHEUER. Well, we know the problem was important. What we want to know is, what did you do about the problem when you were warned about it for the third successive time? What happened after that August meeting?

Mr. WEEKS. The key items that happened after that was the studies that Admiral Truly has already spoken to.

Mr. SCHEUER. What did you learn from those studies?

Mr. WEEKS. That there was, essentially, as we have found now—it's about a 2-year program——

Mr. SCHEUER. That essentially what?

Mr. WEEKS. That it's about a 2-year program to bring the capture tang and any changes into that joint, to eliminate all of those problems that Mr. John Thomas talked about.

Mr. SCHEUER. Now, I don't understand that. It was a 6-week program that just took place to put together the data base that tells you that under no circumstances should this launch take place. Now, what I want to know——

Mr. WEEKS. Now, wait a minute.

Mr. SCHEUER. What all of us want to know is——

Mr. WEEKS. Wait a minute. "Under no circumstances"—I believe really, Mr. Scheuer, you——

Mr. SCHEUER. Scheuer.

Mr. WEEKS. Scheuer, excuse me.

The conclusion of that briefing given to us on August 19 was, it is safe to continue flying the existing design as long as joints are leak-tested with 200 PSI stabilization pressure, and are free of contamination in the seal areas, and meet the O-ring squeeze requirements.

Now, Marshall did proceed with a number of hardware things that were put into the filament-wound case qual test motor. They were basically three; in addition to all this study effort, there were three changes made in the qual motor of the filament-wound case because that was coming along and was an opportunity to put them in. And so we inserted into the qual motor program the fixes that I will now relate. There were basically three of them.

As Admiral Truly said, in July 1985 we ordered those 72 forgings with the extra material so that we can now, for the fix that we're going to have to do, provide the captured tang to stop the rotation. And that decision——

Mr. SCHEUER. Let me cut you off there——

Mr. WEEKS. I really think that to get the three things that were quite fundamental as a result of that——

Mr. ROE. If the gentlemen will both suspend. There is a bit of excitement in the air because we are trying to get to certain facts.

I think Mr. Scheuer had asked you in the initial question, which you really didn't answer—but if I could impose on the distinguished gentleman from New York to allow the witness to make his observations, then let's go back then and restructure our questions. Is that satisfactory?

Mr. SCHEUER. Very good.

Mr. ROE. So we'll give you the courtesy of giving you the time to answer.

Mr. WEEKS. Very good. I appreciate that.

So these—in addition to those studies that Admiral Truly spoke to, there were these three things that we put into the hardware. The 72 forgings were ordered because we knew the rotation problem was serious, and we had changed the design in the filament-wound case so that it did have a captured tang. That decision of proceeding with those 72 forgings is now saving us 6 to 9 months in the implementation program that Mr. John Thomas is heading up that would have delayed us more had we not made that decision. These forgings, in fact, are already at Rohr in San Diego——

Mr. ROE. Can the gentleman, just for clarity, explain to the committee what he means by forgings and where the forgings are located?

Mr. WEEKS. OK. The solid rocket motor is composed of a lot of spun forgings that are 146 inches in diameter and 12 feet long. I think Mr. Lee showed that. It takes two of those forgings, properly machined, to make up a single segment that can then be poured with propellant with, I think, as you, Mr. Roe, spoke to, of the joint that is covered over that is the same sort of joint. And so that's what those forgings are. They're spun; they're done by the Ladisch Corp. up in Milwaukee, and then they are shipped to Rohr in California for machining. And already, with that decision that we made to move out on those forgings, we've gained ourselves 6 to 9 months that we would otherwise have due to this terrible accident. And we changed two of the three case joints as a research project, changing the O-rings in two of the three in this qual motor, which was for the filament-wound case, and that was to improve the sealing.

And the last change of the hardware that was put into the qual motor, into the filament-wound case qual motor, and that stops the rotation, and that one is down in the throat area. The basic idea of the captured tang, which is a very likely candidate for the way we will fix the joint for the final—for when we get flying, is a captured tang that forbids the rotation to exceed more than about nineteen-thousandths of an inch. And that, in addition to the study effort, are very positive things that were done by Marshall and by Thiokol to move forward in this area of improving the O-ring erosion which occurred many times during the past 2 years.

Mr. ROE. All right. Now, if we can get back to our continuity, Mr. Weeks. We thank you for your explanation, but I believe what Mr. Scheuer is about to do is to evolve a set of questions that really are not looking for long, technical explanations, and I mean no effrontery to your expertise, but what actually happened? What did we do? And that's what——

Mr. SCHEUER. Can I rephrase my questions, Mr. Chairman?

Mr. ROE. Yes, sure.

Mr. SCHEUER. Let's rephrase the questions because maybe I wasn't sufficiently clear.

Following the meeting on August 19, where you were urged to make efforts to continue at an accelerated pace the elimination of the seal erosion, where you were urged to make additional tests for establishing margins of safety for O-rings, conditions which apparently impelled the Commission to write that: The O-ring history presented at level I at NASA headquarters in August 1985 was sufficiently detailed to require corrective action prior to the next flight."

Now, having been urged to make an accelerated research and development effort to eliminate seal erosion and to establish margins for safety for eroded C-rings—for eroded O-rings—what did you do?

Mr. WEEKS. The accelerated program was very clear in those three things I just told you that were put into the dual motor test for the filament-wound case, which were genuine improvements to reduce the probability of erosion occurring in those joints.

Mr. ROE. Will the gentleman yield at that point for a point of clarity?

Mr. SCHEUER. Yes.

Mr. ROE. Did you not say two things, as I understand it, when the discussion took place that the results of the—the review of the discussion indicated that if you were to correct the system, that it would take 2 years?

Mr. WEEKS. At the time period that we were doing that, the best estimate that we had for capture tang design configuration was about 2 years.

Mr. ROE. All I'm simply trying to get at is just simply to elucidate your specific statements and facts you made; either they are correct or not. Therefore, do I assume from that—if the gentleman will indulge me further—do I assume from that that if I'm talking to you and we're deciding we have a problem, and you say, well, we do have a problem, we've discussed it—well, OK, now. I'm concerned about that; what I want to do is get that totally corrected so that we do not have any more problems. In order to pursue that course of action, how long approximately do you think it would take? And then you respond to me and you say, well, from my best judgment it would take approximately 2 years.

Is that an accurate observation of your point?

Mr. WEEKS. Yes, sir.

Mr. SCHEUER. Can I take it from there, Mr. Chairman?

Mr. ROE. Yes, you can, of course. I just wanted to clarify that.

Mr. SCHEUER. Now, there was a life-threatening condition there which the Commission said should have been corrected prior to the next flight, OK? Do you disagree with this conclusion? Do you feel that research should have gone on over the 2 years that you suggest it would take, while 25 or 30 additional space flights were being carried out? Should those two things have happened simultaneously or concurrently?

Mr. WEEKS. Well, Mr. Scheuer, it is much easier to look at this thing with 20/20 hindsight, but I still remind you of the following things that we knew at that time.

When the briefing was presented to us on August 19, 1985—as you will look in the briefing that was provided to the Commission on February 10—there was no temperature data presented that showed that the resiliency was such a critical factor. It wasn't until after the disaster of 51–L that I actually saw the resiliency data that showed that Viton, which is the O-ring material that we've been using, is so slow to recover at very low temperatures——

Mr. SCHEUER. Will the gentleman——

Mr. WEEKS [continuing]. That was not brought out——

Mr. SCHEUER. Mr. Weeks—Mr. Weeks, we are engaged here, and let us admit an effort at Monday morning quarterbacking. Should we be doing something else? Should we not all be trying to find out what the problems were and what should have happened that didn't happen that produced that awful accident?

Mr. WEEKS. I——

Mr. SCHEUER. Of course we should; there's no point in debating that.

Now, what I'm suggesting is that you had in your possession—I mean the decisionmakers, the corporate decisionmakers at NASA headquarters—three separate warnings that should have given you notice that this launch shouldn't take place until these problems that were identified were solved. That's what the Commission says.

Let me read it to you over again. I read it to you once before; I'll read it again.

"The O-ring erosion history presented to Level 1 at NASA Headquarters in August of 1985"—at the meeting at which you were present—"was sufficiently detailed to require corrective action prior to the next flight."

Now, do you disagree with that?

Mr. WEEKS. In 20/20 hindsight, I totally agree with you.

Mr. SCHEUER. OK. Now, we're looking at this from 20/20 hindsight. We're all trying to learn some lessons. We're all trying to learn some lessons, and frankly, there may be some lessons on this whole tragic series of events that Congress could learn from. Maybe we didn't do as much as we could have in funding, in encouragement, in oversight. There's probably enough blame to go around for everybody. There are no superpeople here, no supermen or women who are pointing the blame at anybody else. We are all in this together; we are all trying to learn how to avoid this awful catastrophe in the future and move forward successfully, to retake America's supreme place in space.

Mr. WEEKS. I cannot disagree with you, sir.

Mr. SCHEUER. Pardon?

Mr. WEEKS. I cannot disagree with you, that it would be extremely wise if we could have seen to do this $5 million effort that took 6 weeks——

Mr. SCHEUER. Well, what I'm asking you——

Mr. WEEKS [continuing]. In September of 1985.

Mr. SCHEUER. Right. What efforts did take place?

Mr. WEEKS. I wish I could relive that history and do it.

Mr. SCHEUER. That may be enough for my purposes.

Mr. ROE. Will the gentleman yield? I want to get another point on the record.

Mr. SCHEUER. Let me ask one more question.

Mr. ROE. Well, it's a point of clarity that's not clear, Jim.

Mr. SCHEUER. I yield to my chairman.

Mr. ROE. The gentleman, in making his earlier testimony—we solidified the point of view of the 2 years, which we agreed on.

You made another statement, which I think is important. The second statement that you made, that it was determined in the course of that discussion—as I recall what you said—that even though the severity of the issue was understood, that it was decided that it wasn't that severe that you could not proceed with additional launchings, or whatever that meant, even though you would be doing some redesigning as you went along. Did I not understand you to make that comment?

Mr. WEEKS. That's correct, and I think that the statement at the conclusion of the briefing is quite significant in that it is safe to continue flying the existing design as long as we did those three things that are in that briefing.

Mr. ROE. Well, if the gentleman would expand on that further. Therefore, there are a group of people—whomever they were—that participated at this particular meeting, reviewed these facts that were available, and they determined two things, according to your testimony. One, they determined that if everything—if they had their "druthers," or whatever the case may be, it would take 2 years in their judgment to be able to correct that; but in spite of that decision, they took and made the second judgment. And the second judgment, well, we can continue to fly. We'll start the mechanisms going to get this corrected, but we can continue to fly until we get that done. Isn't that the decision that was made, according to what you're saying?

Mr. WEEKS. That is correct.

Mr. ROE. Therefore, some people who were at that specific meeting had to be the people who made that specific decision.

Mr. WEEKS. That's correct.

Mr. ROE. Is that a fair commentary?

Mr. WEEKS. That's correct.

Mr. ROE. Could we have a list of the people who participated?

Mr. WEEKS. I have it right here.

Mr. ROE. Would you submit the list for the record, please?

Mr. SCHEUER. Was Jesse Moore at that meeting?

Mr. WEEKS. No, sir. Mr. Moore was——

Mr. ROE. Well, let me finish the first parliamentary issue first, Mr. Scheuer, if I may.

Mr. SCHEUER. Right. Right.

Mr. ROE. Therefore the gentleman would submit for the record a list of the names of the people that participated in that meeting.

[Material referred to follows:]

August 19, 1985 - O-Ring Briefing at NASA Headquarters

Morton-Thiokol, Wasatch Division

J.E. Mason	Senior Vice President and General Manager
C.C. Wiggins	Space Division Vice President and General Manager
J.C. Kilminster	Space Booster Program Vice President
A.J. McDonald	Solid Rocket Motor Project Director
C.A. Speak	Filament Wound Case Program Manager
F.J. Ross	Washington D.C. Office - Marketing Manager

George C. Marshall Space Flight Center

L.B. Mulloy	Solid Rocket Booster Program Manager
R. Schwinghamer	Materials and Processes Laboratory Director

NASA Headquarters

L.M. Weeks	Office of Space Flight Deputy Associate Administrator (Technical)
D.L. Winterhalter	Shuttle Propulsion Division Acting Director
W.H. Hamby	STS Program Integration Deputy Director
P.F. Wetzel	Solid Rocket Booster Programs Chief
P.N. Herr	Solid Rocket Motor Program Manager
H. Quong	Reliability, Maintainability, and Quality Assurance Director (Chief Engineer's Office)

Mr. ROE. The Chair recognizes the gentleman from New York.

Mr. SENSENBRENNER. Mr. Chairman, I'd like a point of clarification. I thought we were operating under the 5-minute rule here, and it's been a half an hour and there have been a lot of other members that have been very patiently waiting.

Mr. ROE. Well, that's probably the Chair's fault because this afternoon the Chair had decided, because of specific questions where people had been waiting all day, that we'd give people a little more latitude. But it is not the intention of the chairman to turn anybody off, and we'll give the gentleman the same courtesies in return.

The gentleman from New York.

Mr. SCHEUER. Thank you.

Mr. Weeks, you were telling us about Jesse Moore's presence.

Mr. WEEKS. Yes, sir.

Mr. SCHEUER. Was he at the meeting?

Mr. WEEKS. No, sir. He had planned to go to the meeting, but he was—some other prior pressure caused him to go to another meeting. But I did brief Mr. Moore that evening, as we were wont to do in the early morning and evening. I briefed him on the results of that and told him about the briefing and showed him the briefing, and as we left that evening I said I was still not quite satisfied and I wanted to call someone that I had great trust in, and I so did do that, to Mr. George Hardy of the Marshall Space Flight Center who had headed up the SRB for many years and then had moved up to be deputy engineering. And I had great faith in his judgment, and I asked him, how bad is it? And he allayed my fears, and I think it came from the fact that we did do a test that showed that we had a factor of safety of four on the 0.032-inch erosion that occurred.

Mr. SCHEUER. Isn't it clear that we really didn't know enough at that time to really come to any conclusions about a factor of safety except to know that we had life-threatening conditions to which we ought to have achieved answers before we went ahead? Isn't this what the report is all about, that corrective action was required prior to the next flight? And the fact is that you have learned more in this 6 weeks of collective effort through the expenditure of $5 million and the application of 200 trained scientific and technical minds, than you knew through that entire 2-year effort up to the date of launch? Isn't that true? You really didn't know what the problem was with the seal erosion and with the margins for safety for eroded O-rings as of the time that that launch took place? Isn't that true?

Mr. WEEKS. I essentially agree with you, sir. That joint, with the putty problem, with the rotation problem, with the——

Mr. SCHEUER. Let's not get into technicalities.

Mr. WEEKS [continuing]. Temperature problems, are all very complicated and I agree that the effort after was extremely effective and we learned immensely after the accident.

Mr. SCHEUER. You learned immensely. Wouldn't you say that, with the benefit of hindsight, that following the warnings of that August 19 meeting to accelerate the pace of research into seal erosion, and to accelerate the tests for establishing margins of safety for eroded O-rings, the simple, clear message of that briefing was, do your homework before going ahead with another launch because you have life-threatening conditions that are there which must be faced and for which solutions must be found? Wasn't that the clear meaning of that briefing on August 19?

Mr. WEEKS. Yes, sir.

Mr. SCHEUER. Why wasn't that done? Your boss knew about it; you reported to him that evening.

Looking at it in hindsight, what have we got to learn? Why didn't you and Mr. Moore and the other decisionmakers follow up on those recommendations and either do the work in the next 6 weeks—which would have been a replica of what you did in the last 6 weeks or so—or why didn't you postpone the launch until you had done your homework?

Mr. WEEKS. If we had known that clearly how crisply to do this problem, we certainly should have done it.

Mr. PACKARD. Mr. Chairman, may I just—would the gentleman yield for just a moment?

Mr. SCHEUER. I'll be happy to yield.

Mr. ROE. He was just finishing.

Mr. PACKARD. So that we can conclude this matter and not hammer on something that's not redoable, I think that the Commission's report makes a rather cogent statement that reflects directly on what the gentleman from New York is pursuing.

It says, "If the decisionmakers had known all the facts, it is highly unlikely that they would have decided to launch 51-L on January 28, 1986." And I think that that's what we're hearing from the witnesses. And I think that's what we're trying to determine, is how to avoid repeating this problem again. And I'm not sure that it would be productive to pursue it further.

Mr. ROE. Well, the Chair has allowed this discussion to go this far simply because of the point of view that I believe that it's a subliminal issue—Mr. Weeks, you have become quite, what would you say, well known throughout the Nation—what Mr. Scheuer wants to do, and the gentleman from California understands, is just to get on the record the sequence of events that took place. And I think you've done a good job in making that presentation.

Mr. SCHEUER. Mr. Chairman, may I add one more sentence?

Mr. ROE. Yes.

Mr. SCHEUER. I think this has been very helpful, and I wish to express my feeling that Mr. Weeks has been forthcoming in his testimony. It took a little time, but he's given us what seems to be a NASA view. They should have known a lot more before they proceeded, in hindsight. Any other conclusion would be difficult to come to.

There's been a lot of fingerpointing here at Marshall, but I think it's fair to say that central headquarters, also, has played a major role in this, and I think that we shouldn't forget this as we proceed with these hearings, Mr. Chairman. I hope we'll have a chance to ask Mr. Weeks to come back. He's been very helpful today. I appreciate his forthcoming testimony, and I hope I will have the chance to ask him further questions.

Mr. ROE. I thank the gentleman from New York.

Mr. PACKARD. Would the gentleman yield?

Mr. SCHEUER. Can I yield to my colleague, Mr. Nelson?

Mr. ROE. If I could just chair the meeting, then I will let you yield.

Mr. SCHEUER. Very good.

Mr. ROE. I would like to make it clear to all of our Members that there's no one that's going to—we seem to have—I don't know; maybe it's the Ides of June. There seems to be a little testiness today, unnecessarily. I think the Chair has been overabundantly generous to every Member about any particular issue, any particular area that they chose to make their points, to be able to make them. And I intend to see that the hearing continues under that decorum and under that direction. And no one will be precluded from their point and their opportunity. I want to make that point abundantly clear.

I want to make another point clear. I think it ought to be said at this point, in this stage of the hearings, we have work yet to do and very important work to do. And I think we've successfully come to a point where, as far as the obligations and responsibilities of the Commission, they have made a report. We are now very, very carefully and very legitimately following up on it, point to point. Everybody, practically, at this table one time or another has said there's plenty of blame to go around. There is for everybody. That is not our mission. Our fundamental mission is to understand what happened, why it happened, and how we correct it and what policies we set for the Nation. That is the purpose of this hearing.

Now, there will be some blood and some scar tissue, I'm sure, when we're done. But it's going to be fair and it's going to be honest and it's going to be just, and I think that's the direction in which we have been continuing and that's the direction in which we will continue.

Now, having said that, I will yield to the distinguished gentleman from Florida, Mr. William Nelson, because he has a series of questions he would like to ask.

The Chair recognizes the distinguished gentleman from Florida.

Mr. NELSON. I appreciate it. The reason I had asked the gentleman from New York to yield was that I just wanted to follow up, just with a question or two, to Mr. Weeks.

After this famous meeting that occurred in August, did you or anyone else issue instructions to Marshall or to Kennedy to take care of those three problems that were noted in the Thiokol report?

Mr. WEEKS. Yes, Mr. Paul Herr sent a memo to Marshall following up on the August 19 meeting, and I can't remember the date of Mr. Herr's memo.

Mr. NELSON. All right. May we have a copy of that, please?

Mr. WEEKS. We will find it for you. Yes, it's available.

Mr. NELSON. Fine. Send that to me personally, please, and to Mr. Scheuer.

[The information follows:]

Material requested for the record on page 149, line 3651, by Mr. Nelson on June 12, 1986.

Memorandum dated August 23, 1985, singed by Paul Herr reference Headquarters, meeting on SRM "o" ring briefings is enclosed.

MPS August 23, 1985

TO: Marshall Space Flight Center
SA41/Manager, Solid Rocket Booster Project

FROM: MPS/Manager, Solid Rocket Motor Program

SUBJECT: Headquarters SRM FWC-STA/"O" Ring Briefings

As a follow-up to the SRM briefings to Headquarters on August 19, 1985, please provide the following:

I. FWC-STA

a. pre-launch loads at WTR and ETR with and without winds.

b. inspection plans for VLS-1 pre and post FRF.

c. rationale for new FWC segment - could DM-7 segment be used to avoid costs?

d. results of forward segment inspection.

e. pictures of failed aft segment.

II. "O" Rings

a. provide a copy of "O" ring validated (TWR-14952)

b. schedule and cost to incorporate the captive feature on future segment buys.

c. data on pre launch loads causing joint rotation.

d. results of post flight torque tests of nozzle and ingiter bolts.

Thanks again for two well done briefings on the SRM here at Headquarters.

Paul N. Herr

Mr. NELSON. All right. Now, Mr. Weeks, what specifically does it mean in the Thiokol report when it says, "meet O-ring squeeze requirements?"

Mr. WEEKS. The basic limit, Mr. Nelson, on the minimum squeeze is 7½ percent of the diameter of the O-ring itself, so that means roughly that you shall not have a squeeze less than 20 thousandths, approximately, on the 280 thousandths O-ring.

Mr. NELSON. Were those requirements met on 51-L?

Mr. WEEKS. I believe so. In fact, I think that John Thomas could probably answer that, but I believe it was in the vicinity of .035.

Mr. THOMAS. Yes, sir, that is correct. They were met.

Mr. NELSON. OK. Now, was there a concern about excess squeeze or maximum squeeze?

Mr. WEEKS. Yes, I believe so. But as I understood the problem then—and I guess as I do now—the more serious one is when you get the rotation with the minimum squeeze, which then, if you don't have good resilience, doesn't fill up the gap and contain the gasses. But I believe there is a concern at the high one, but I don't believe it's the crucially serious one.

Mr. NELSON. All right. Were these squeeze requirements met on all of the flights after August 19, 1985?

Mr. WEEKS. I can't be totally authoritative, but I've never heard anyone say that they did not.

Mr. NELSON. OK.

Mr. Thomas, do you have any information with regard to that?

Mr. THOMAS. No, I don't.

Mr. NELSON. OK.

Supply that for us, Mr. Weeks, if you will.

[Material to be supplied follows:]

Material Requested for the Record on Page 151, Line 3684, By Mr. Nelson on June 12, 1986.

The calculated O-ring squeeze, using actual measured case tang and clevis dimensions for 51-I (flew on August 27, 1985) and subsequent missions are shown below:

FIELD JOINT

STS		FWD	CTR	AFT
51-I	LH	11.2%	11.5%	11.5%
	RH	12.8%	15.3%	14.6%
51-J	LH	9.8%	16.0%	16.6%
	RH	13.9%	16.1%	14.3%
61-A	LH	11.5%	12.5%	17.0%
	RH	16.0%	15.6%	15.6%
61-B	LH	13.9%	15.3%	13.2%
	RH	8.8%	16.5%	12.9%
61-L	LH	14.6%	10.5%	16.3%
	RH	13.9%	16.3%	14.2%
51-L	LH	10.2%	13.2%	13.4%
	RH	12.5%	13.1%	14.3%

Mr. NELSON. OK. Mr. Chairman, I want to now pick up the question that I asked in Dr. Fletcher's absence yesterday morning. I asked Admiral Truly, and he said that Mr. Lee would supply the answer today, so if Mr. Lee would come up.

Mr. ROE. Mr. Lee, please.

Mr. NELSON. I further privately discussed this with Dr. Fletcher, and it gets into the question of the testing and analysis requirements on the whole SRB—not just the joint, the whole SRB. Under the design specs it was to go down on natural environment down to 31 degrees, and under induced environment it was to go down to 21 degrees. And there were supposed to be testing and analysis on this, and the reason this was raised was when you briefed this committee down at the Kennedy Space Center on Friday, you told us that you had no evidence that such testing and analysis in fact was done.

Would you restate that for the record, as to what you told us Friday?

Mr. LEE. Yes, sir, Mr. Nelson.

With your permission, you stated that the lower limit on the induced temperature was 21—was 26, I believe, 26 degrees Fahrenheit?

Mr. NELSON. No, sir; not in these documents. It says 21 in there, but be that as it may, let's go on.

Mr. LEE. It is, in fact, 26 degrees.

The finding that the Commission's production and development——

Mr. NELSON. Well, let's just clarify that. I have a document here—as long as we're going to get specific—NASA Technical Memorandum. Is this the cover page for it?

Mr. LEE. I believe so.

Mr. NELSON. OK. Dated November 19, 1973, Marshall Space Flight Center. It gives temperature, degrees Fahrenheit; talks about the aft attachment; talks temperature in degrees Fahrenheit; hot, max of 96; cold, minimum of 21.

Mr. LEE. I'm not familiar with that particular document. I was referring to the overall systems specification that is from the shuttle—overall specification which is imposed on our element contractors, and that is in fact 26 to 120 degrees Fahrenheit, induced.

Mr. NELSON. All right. It's a minor point; we'll clarify it later on between the exchange of paper.

Dr. FLETCHER. Mr. Nelson, did you say 1973?

Mr. NELSON. That's correct. That's the date.

Dr. FLETCHER. I'm not sure, but that could have been before Morton Thiokol was selected. I think we ought to check the date, but I believe that was an early spec that may have been changed by the time we had the solid rocket contractor on board.

Mr. NELSON. All right, we'll check it.

Go ahead.

Mr. LEE. Mr. Sutter's commission team, which I supported, found that the requirements for that specification were satisfied by the Morton Thiokol Co. through either qualification testing, analysis, or inspection or acceptance testing. Now, in the case of the seal joint itself, for the certification—the acceptance of the certification of that joint—it was specified to be done by analysis. That was proposed by the Morton Thiokol Co., and the Marshall Space Flight Center accepted that, by analysis.

As I stated this morning, the interpretation of that induced requirement by Morton Thiokol was not associated with vertical flight, but more as a storage temperature. So, given that situation, their limitation or band, range of temperatures for qualification, to them was that associated with the mean bulk temperature, which they believed encompassed all environmental requirements for the motor from a qualification standpoint—was 40 to 90 degrees. Now, that's what they did in fact state to our team when we reviewed this.

It is my interpretation and the writer of the specification, the keeper of that spec at JSC, and the project office—the solid rocket booster project office—at Marshall, that the intent was to be 26 to 120 through vertical flight. Now, that makes a difference in the way you go about satisfying or certifying them. In any event, the certification method was by analysis, and the data presented to certify that environment to the Government, if you will, was a MIL-SPEC on the O-ring which states clearly that the O-ring can be operated between the temperatures of minus 30 and 500. Now, the interpretation of the meaning of that certification on the part of the Government was that the O-ring was the critical part; it did, in fact—was usable through those ranges.

Now, in hindsight it is determined by Mr. Sutter's team that the proper imposition, if you will, for the method of certification probably should have been by test, which it wasn't, in light of the accident; and the stated satisfaction, if you will, by analysis of using only the O-ring spec was inadequate or improper.

So the issue is around the interpretation of the specification and, in light of the accident, we should have gone through a full-scale qualification through all those environments. So there was a misinterpretation and probably a lack of imposition, if you will, or inadequate imposition of the method of qualification. And that was, in fact, the issue that our team came out with, is that under items of this type of criticality, the method of certification and qualification should be further scrutinized and ensure that they do in fact go through the full qualification range. That was the intent of the whole thing. Not to imply that Morton Thiokol did not satisfy their contractual requirements.

Mr. Nelson. Friday, you showed us this same chart that you showed us today, which said "significant findings," and the first one is, "qualification not accomplished to required spec limits."

Mr. Lee. That's right.

Mr. Nelson. You explained that Friday at the Kennedy Space Center, and you said that the adequate testing and analysis had not been done. And when I asked why, you said nobody knows why.

Mr. Lee. I'm sorry, I don't remember giving exactly that answer. I believe, in answer to the question, I stated that the people who were there at the time in the development program, back in the late 1970's who were in fact required to interpret the adequacy of that certification, who actually signed off on the certification and qualification, are no longer with us. I believe that was the intent of my answer, as opposed to "no one knew."

Mr. NELSON. OK. So what you are saying today is that analysis was required, which in fact the documentation shows, for both the natural environment and the induced environment; and you're saying that the interpretation of what analysis should be was that it would go down to 26 degrees in a stored condition; is that correct?

Mr. LEE. Yes, sir.

Mr. NELSON. But that's not what the design specs call for, and I read from 3.2.2.1.17.2, which is on a document entitled, "Space Shuttle Flight and Ground System Specification," dated September 30, 1983, from the Johnson Space Center, and let me read for you: "Induced environment: Each element shall be capable of withstanding the induced environment imposed during transportation, ground operations, handling, and flight operations." Flight operations, OK? Now, how could they come to an interpretation that that meant only for storage?

Mr. LEE. I don't know that, Congressman. I only know that the people on my team who evaluated it interpret it the same way you do. The writer of the document interprets it the same way you do, and I think the project office does. I cannot answer for why Morton Thiokol did not interpret it that same way during the development program.

Mr. NELSON. Well, first of all, we have two verification completion notices that have been signed. This induced environment is in fact one of the verification requirements completed and signed off. One verification completion notice is done just before STS-1, and the second one is done just before STS-5. So the obvious question is, why were they signed?

Mr. LEE. Are they Government signatures?

Mr. NELSON. Yes. There's a whole raft of signatures here.

Mr. LEE. Well, again, the basis for that certification was, in fact, what was interpreted to be the completion of the analysis, and that was the O-ring itself was in fact a MILSPEC designed to go from minus 30 to 500 degrees Fahrenheit.

Mr. NELSON. Well, you're talking about the—that doesn't answer the question. The answer to the question—what you're saying is that you don't know why these were signed because the analysis was not done according to the design criteria.

Mr. LEE. No, sir. I'm saying that it was established that the certification would be completed by analysis. I'm also stating that the analysis in this case was the recognition that the O-ring itself was good to be used between the temperatures of minus 30 and 500 degrees; that's the documentation which I have seen that was used to say this is, in fact, certified for those temperatures.

Mr. NELSON. If the design specs say otherwise, then who made that determination that they were going to test—or analyze, in this case, analysis—to a different standard than in the specs?

Mr. LEE. Well, the determination to certify it by analysis was proposed by Thiokol and approved by NASA. The method for that analysis happened to be the MILSPEC, and the MILSPEC calls for a temperature range which encompasses the 26 degrees to 120 degrees.

Mr. ROE. Will the gentleman yield for a clarity, please?

Mr. NELSON. Certainly.

Mr. ROE. The question that's being asked, and the distinguished gentleman, Mr. Lee, comes back and says "they decided that we would do an analysis." Then we would have him carrying on about 20 minutes of dialog relating thereto. But the fundamental question is, Who decided we would use the analysis approach? Who made that decision?

Mr. LEE. That was approved at the project office level within Marshall and our project office level at Morton Thiokol.

Mr. ROE. Now, think what you said. It was approved by, and I asked you who made the decision.

Mr. LEE. Oh.

Mr. ROE. Did it come from Thiokol? Did it come from NASA? Was it from Thiokol-NASA corroborative?

Mr. LEE. I'm sorry. It was proposed by Thiokol, by the company.

Mr. ROE. So are we saying, for the record, that that initial decision to use the analysis approach was suggested or recommended by Thiokol; but however, after review, the NASA authorities—whoever had the jurisdiction—approved that approach. Is that correct, for the record?

Mr. LEE. Yes, sir.

Mr. ROE. The gentleman from Florida will proceed.

Mr. NELSON. All right. Thank you, Mr. Chairman.

I think another hindrance in our conversation here—and, you know, isn't that interesting? You know, it's just a human foible of communication; and that, in large part, Dr. Fletcher, is what the Rogers Commission has pointed out. It's a mistake in communication that occurred in so many areas.

So in trying to hone in the clarity of our communication, let's make sure. You're talking about—that an analysis was determined on the basis of the O-ring itself. But that's not what the design requirement was. The design requirement is for everything on the SRB, not just the O-ring. If in fact this document that I have is an accurate one, here, entitled—from Johnson Space Center—"Space Shuttle Flight and Ground Systems Specification, Level 2 Program, Definition and Requirements," September 30, 1983, and it clearly says what are the design environments, the natural environment as well as the induced environment. And it clearly includes flight operations, and it says each element. It doesn't say just the O-rings.

So when you get into your analysis and then you start signing off on these verification completions—Mr. Lee, I'm not picking on you. You all have done an excellent job. By the way, Dr. Fletcher, I wanted to compliment you; you know, what we learned on Friday and subsequent, my private conversations with Chairman Rogers, he thought that your NASA investigatory team did an excellent job, the ones that we've heard the reports from each of the people today, and basically, you know, what you all concluded and reported here today and reported to us last Friday is in fact the same facts that the Commission reported.

But now we find a specific question here. Why were these verifications signed off on for a requirement in the design specs? Does anybody have any clues? Anybody?

Dr. FLETCHER. Mr. Nelson, of course, this happened when I wasn't here, but I'm sure you are aware that there's a difference between a component requirement—which is the O-ring, which had the MILSPEC on it and which was accepted as an analysis—and the system of which it is a part, which includes the O-ring and the groove into which it fits and the whole seal. And I think what we're seeing here is, we accepted the MILSPEC on the O-ring but we didn't have adequate verification that tests were made on the whole system, which is the seal.

Mr. NELSON. Including the putty.

Dr. FLETCHER. That just plain fell through the cracks.

Mr. NELSON. Including the putty.

Mr. LEE. Yes, sir.

Mr. NELSON. The putty wasn't tested down to 26 degrees, was it?

Mr. LEE. That's true.

Mr. NELSON. Well, I'll just yield to my friend from California.

Mr. ROE. The gentleman from California.

Mr. PACKARD. I appreciate that. My line of questioning doesn't necessarily follow on the gentleman's from Florida, although that——

Mr. NELSON. Well, you don't want to break my train of thought, do you?

Mr. PACKARD. I don't and so let me yield back. That was one of the questions I had, but he's pursuing it adequately.

May I ask the chairman to allow him to go ahead and complete?

Mr. ROE. Of course. You'll be next.

Go ahead, the gentleman from Florida.

Mr. NELSON. OK.

How—anyone; Admiral Truly, Dr. Fletcher—how do we go about determining whether or not such analysis was ever made? Do we know in fact today that the analysis was never made down to 26 degrees?

Mr. LEE. I think I can answer that. Because it was a concern to our group, when we found that particular situation around the joint, we did in fact review or attempt to find all documentation, all analyses, all tests to help support that, and we could not find any analyses other than that which has been stated relative to the MILSPEC for the O-ring. And that is, again, Mr. Nelson, one of the reasons that we, as our team, identified this as a finding, because we believed that it was in fact inadequate in the system.

Mr. NELSON. OK. Assuming that that is the case, that you all did not uncover this analysis—documentation of this analysis—assuming that it does not in fact exist, then what can we do to crawl inside the minds of these people, some—looks like about 24 signatures on this page before STS-1 in March 1981, and again in November 1982, before STS-5? What can we do to crawl inside their heads?

Dr. FLETCHER. I guess I'm the experienced manager in terms of team motivation, but basically it doesn't matter, Mr. Nelson, how many signatures are on the document as long as at least one of them has understood the problem, feels responsibility for pursuing the problem in the depth that is necessary, which I indicated was a systems problem, not just a component problem. We need to tighten up and make sure there are at least one—plus a checkup on that person—to make sure that it is done satisfactorily.

Mr. NELSON. OK. If you would do that, and if you would report back to us, I would appreciate it. And, while you're doing that, Dr.

Fletcher, there are some other people that you could perchance go to for additional information, and that is that we understand that a thorough review was made by a group of experts headed by Dr. Walt Williams, and that—so you had on these design specs, you had a lot of people overseeing it. You had Thiokol, you had Marshall, you had this outside group of experts, and the Aerospace Safety Advisory Panel. So let's see if we can crawl inside their heads, as well, and see if we can get any clarification on it.

OK. Mr. Chairman, if I may continue?

Mr. ROE. Yes. Are you on the same vein?

Let me give you a break and let's hear a little bit from——

Mr. NELSON. If you'd like to give me a break, Mr. Chairman, that's fine.

Mr. ROE. Well, you're going to be here for a while and so am I, so let's defer for a moment——

Mr. NELSON. I'd be happy to.

Mr. ROE [continuing]. For the distinguished gentleman from California.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

I want to go back to the O-ring problem and ask some specific questions as to where we go from here, and I need a little background before we do.

In your judgment, as you've reviewed the Commission's report and as you've reviewed your own teams' research, do you feel that cold weather alone, devoid of water and ice in the joint, would have caused the accident? Without water and ice in the O-ring joint, but still having the cold weather, in your opinion would there have been an accident?

Mr. THOMPSON. I think the cold weather was probably the most significant influence in the four or five that John Thomas described today. It took us over the edge. That's my own judgment.

Mr. PACKARD. The cold weather, not the ice?

Mr. THOMPSON. That's correct.

Mr. PACKARD. Of course, the cold weather caused the ice, but that would be——

Mr. THOMPSON. The effect of the cold weather on the O-ring——

Mr. PACKARD. The temperature at 28 degrees or 29 degrees was more critical than the fact that it was ice?

Mr. THOMPSON. That would certainly be my judgment.

Mr. PACKARD. How many O-rings are there on the entire SRB—O-ring joints, excuse me?

Mr. THOMPSON. Two per joint, six field joints——

Mr. PACKARD. I don't mean O-rings, I mean joints. How many joints are there on one of the SRB's?

Mr. THOMPSON. There are six field joints.

Mr. PACKARD. Six? Total joints I'm asking, now, both factory and field.

Mr. THOMPSON. There are 14 total, I believe. Let me——

Mr. PACKARD. Well, all right. It's not critical, the number.

The factory joints—has there been any problem with the factory joints in the history of the equipment and our launch system? Have we had any history of problems as we've returned and recovered and refurbished? Have we looked at the factory joints?

Mr. THOMPSON. Yes, sir. They've been looked at and none have any——

Mr. PACKARD. And as we've looked at those factory joints, have any shown any deterioration of the O-rings?

Mr. THOMPSON. Let me check and make sure we've got no evidence of any erosion—I believe the answer is no, we have not. But in terms of being precise on that and making sure there's absolutely none on any factory joint, I'd like to be able to come back and confirm that there are none. I believe that to be the case.

Mr. PACKARD. So it's anticipated that if you find no history of deterioration of factory O-rings——

Mr. ROE. Would the gentleman yield for——

Mr. PACKARD [continuing]. Then you would not anticipate any redesign of those particular factory joints?

Mr. ROE. Let me add a point that I think is necessary for clarity right at this point.

The question, so that we all understand what we're talking about as I understand it, if the gentleman would yield, is that the configuration of the factory joints is identical with the O-ring configuration, as is the field joint. Is that a correct assumption?

Mr. THOMPSON. Yes, sir.

Mr. ROE. All right. So therefore—just for clarity—what we're saying is that, regardless of what the issues are involved, factory or field, it's identically the same mechanism, same structure?

Mr. PACKARD. Is that correct, Admiral Truly? Because I've gone on that assumption.

Admiral TRULY. The configuration of the O-rings, which was your question, is identical between factory and field joints. There is a design difference, however, because the factory joints are covered with insulation at the factory, with propellant poured over that insulation, and that is the single difference.

Mr. ROE. Well, if the gentleman from California would yield, one of the issues that emerged in the discussion today that related to where that extra smoke came from, came from the exchange of views that the interpretation—I believe Mr. Thomas—that in testing further—I believe it was Mr. Thomas; I don't remember—that it was the insulation that added to that issue. Is that a correct remembrance? The insulation is above and beyond the oil and the grease and whatever and the organic material, Viton rubber or whatever, in the O-ring was part of the smoke. But in addition, what created a more volumetric amount of smoke involved, as you indicated, was some of the burning of the insulation. Is that a correct point? That's what you said. And the question of the gentleman, if I may, is that this same type of insulation that's used in the field O-joint insulation is the same kind of insulation that's used in those joints that are factory sealed. Is that a fair commentary, the gentleman from California?

Mr. PACKARD. Yes.

Mr. ROE. That's what we're trying to find out.

Mr. THOMPSON. Would you give us a minute and let us get the vu-graph——

Mr. PACKARD. Please. Let me pursue with my questions and then come back, if I may.

The thrust of my question—or the end result—is to find out if we're having a different history with the factory joints than we are the field joints. I think we are; is that correct? Obviously, we're not showing a problem with the factory joints.

Two questions that I would like answered, one very simple. If we see no real problem and have no real history of problems with the factory joints, will they be included in any redesign? Will it be necessary to redesign those, along with the field joints?

Mr. THOMPSON. I know that's all being looked at, but let's get John Thomas to answer that. He's heading up the redesign team.

Mr. THOMAS. First, to clarify the configuration. The field joint from here outboard looks identical. From here inboard, the insulation comes right down this way—the edge of the insulation comes right down this way—and back against the case, and all this area here is then filled with propellant. So there is no gap in the insulation at this joint; it's a continuous path of insulation over the joint.

Mr. PACKARD. Let me pursue it a little bit, then.

The rotation has proven to be one of the problems under cold weather conditions relating to the accident. Do we find the same rotation problems at the factory joints as we do at the field joints?

Mr. THOMAS. Yes, sir, just to a little bit lesser degree because of the influence of the continuous insulation across the skin. But it is, for all intents and purposes, the same.

Mr. PACKARD. And do field joints have the same—are they subject to the same problems of the cold weather as the field joints?

Mr. THOMAS. Yes, sir, they are.

Mr. PACKARD. And so they could fail under a set of circumstances similar to what we found failure, here in this accident?

Mr. THOMAS. It is conceivable that they could fail under that set of circumstances. However, the joint is susceptible to the same degree of hazard as is the case, about 6 inches away from it. And that is that if the insulation burns through, or for some reason is fractured to the case, even at the point where there is not a joint, you would have erosion of the metal and weakening of the metal and a failure just as you would a joint. So in this case, where you have insulation over it, it is essentially a continuation of the membrane.

Mr. PACKARD. Well, certainly, we know that—we've seen no breakdown or evidence of failure of other joints other than the one that ultimately has been identified as the cause of this accident.

I'm intrigued by the fact that all of the problems in combination that caused this accident, or the accident-causing joint and those that contributed to the cause of the accident, all fell into one specific area. I'd like to know if that's by chance, by coincidence, or whether in fact that is predictable and was predictable.

We're looking now at about the 307-degree point on the field joint in the rear right booster. It was the coldest spot on that booster at that particular time of day when launch took place. It was the most—it had the most stress because it was next to the strut, and also because it happened to be the point of the maximum O-ring squeeze. All of that came at the same point, or essentially the same general area on that joint. Is that simply coincidental? Or in the shipping of it, where it goes out of round, do they ship that section, that particular section of the SRB, in the same configuration so that every section for every flight would be out of round and put the same kind of squeeze pressure around that same strut, that 307-degree area?

Mr. THOMAS. The cases are shipped—all are shipped in the same orientation, that is, with the 90-degree or tunnel position up on the rail car. They're all shipped in that configuration.

Mr. PACKARD. So that every out of round correction would put the stress or the maximum O-ring squeeze at the same point, flight after flight?

Mr. THOMAS. I would say not precisely at the same point, but on that side of the vehicle.

Mr. PACKARD. So that it wasn't coincident that all things seemed to zero in to that one specific area?

Mr. THOMAS. I think there—excuse me, sir.

Mr. PACKARD. It certainly wasn't designed that way, but that's the way it happens to be. OK.

I'd like to pursue if I may, Mr. Chairman, just briefly, this whole question of cannibalism and the extra workload—and we can turn the lights on if we like.

It is alarming that 45 parts out of 300 had to be cannibalized from another shuttle or another piece of equipment. That has to mean that there was a significant amount of cannibalism from flight L–51 to the previous flight, which I think our gentleman from Florida was on. Is that true?

Mr. UTSMAN. Yes, sir.

Mr. PACKARD. I have to assume that the very process, the human process, of removing from one and putting it onto another simply geometrically increases the potential for error, for problems. Is that correct?

Mr. UTSMAN. That's correct, sir.

Mr. PACKARD. It not only increases the possibility of error, but it certainly contributes substantially in this case, where it became almost a graduating process of increasing the workload of the people. As we increased the amount of cannibalism, the amount of change from one flight to another to get the flight off on schedule, that became—and that was exacerbated by increasing the flight schedule from what was initially planned to be 16 and then up to 24, or over a process—that must have put incredible pressure on the crew—not the crew of the flight, but the personnel involved in making these changes. Is that correct?

Mr. UTSMAN. It was one of the frustrations that did get to our launch teams.

Mr. PACKARD. It came back to this committee long before the accident that this was becoming a problem, that we were overworking, possibly, the personnel. That, in addition, could create enough of a problem for where—well, when people are overworked, sometimes things can be overlooked.

Is that because we have not had adequate spare parts in inventory?

Mr. UTSMAN. Yes. The reason you cannibalize is because you don't have a spare part to draw from the shelf.

Mr. PACKARD. And not having adequate spare parts, did we find that in this particular case that we had to remove from other pieces of equipment, parts that were—that are now in retrospect attributable to the accident, the O-ring joint and any of that area?

Mr. UTSMAN. No, sir. All those attributed to the joints are expendable parts.

Mr. PACKARD. I would have assumed that.

So what parts generally are cannibalized?

Mr. UTSMAN. It's normally parts that are high value, critical parts on the orbiter, and the common thread that normally runs is that there has been some problem where they are in a repair cycle, or the repair rate may have been slightly higher than anticipated.

Mr. PACKARD. What effect will that have, or would that have had, on the Galileo and Ulysses missions that were scheduled to fly in May, this past May? Would that have reached a point—it was a progressive point and getting worse and worse as far as the cannibalism and also the extra workload that that was creating? Would that have created a possible delay in those two flights, which had a very narrow window?

Mr. UTSMAN. Obviously, the answer to that is speculation. My own personal feeling is it would have created large frustrations with the work force. I think that it would have forced us to look at priorities and work arounds. My own personal belief, we would have found work arounds, but it certainly would have been a higher work factor and a frustration factor.

Mr. ROE. Would the gentleman yield on that point?

Mr. PACKARD. I'd be happy to yield.

Mr. ROE. For the record, why—just two points. Why don't we have enough spare parts? Is it inadequacy in funding by Congress? Or has there been some other decision process that gets in the way there? For the record.

Dr. FLETCHER. I'd like to start, Mr. Chairman, with that because I have had a chance to look into that, both in my former capacity and more recently.

We have to recall that this is really an R&D Program; sometimes we call it an operational system, but it's really an R&D system. And for R&D systems, you don't really have enough data to go on to get adequate spare parts. Also, you only have four orbiters and the spare parts problem in that kind of a system is a lot different, say, than for a 100-aircraft fleet, especially a mature fleet where you've had some experience on spare parts. I don't want to say we couldn't have done better, because I'm sure we could have; but spare parts is not a trivial issue on any kind of an R&D program of this sort.

Now, having said that, I'm sure there are experts that are closer to it than I am.

Mr. ROE. Well, I think what I'm really trying to get at—if the gentleman will yield further—just for the record purposes, has Congress not provided adequate funding to provide the resources for spare parts? Or has part of the decision been made—whatever the reason may be—on NASA's part?

Dr. FLETCHER. To the best of my recollection, since that has come up before, Congress has provided adequate funds for spare parts. Whatever actions were taken to reduce the number of spare parts, if it was done, was done within NASA.

Mr. NELSON. Mr. Chairman, may I elucidate you further on that subject?

Mr. ROE. If the gentleman from California will yield.

Mr. PACKARD. I'd be happy to yield to the gentleman from Florida.

Mr. NELSON. Indeed, what Dr. Fletcher says is accurate. A case in point is last year. There has been a diversion of some of the funds that were authorized for spare parts by this committee. The specifics of that we can provide through documentation. This committee has come forth, recognizing continually that spare parts is a problem and going to continue to be; and yet, there was an administrative decision within NASA last year, as a case in point, that diverted some of the funds.

Mr. PACKARD. Let me just—if I can reclaim my time——

Mr. ROE. The gentleman from California.

Mr. PACKARD [continuing]. Pursue that for just one further question.

If the policy decision is made, or if budget constraints force that decision, that we would live with three orbiters, and cannibalism continued at the levels that they've been in the past, what kind of problems would that create for us in keeping any kind of a schedule like what we're talking about now, 17 flights per year?

Mr. UTSMAN. It would have created a large problem. We did look at it. Some of our people feel that we would have not been able to meet the schedule.

The key to it would have been to be able to generate a rapid turnaround response on repairs with the various vendors in order to compensate for things not on the shelf. We were working to be able to do that, and that was our only hope of being able to meet the schedule. It would have been extraordinary efforts in the repair cycle.

Mr. PACKARD. Certainly that's going to be a decision that this committee is going to have to grapple with in the future, as to how we deal with the spare parts problem and the cannibalism problem and the additional work that puts onto the personnel that get these off of the ground.

Mr. ROE. Will the gentleman yield at that point?

Mr. PACKARD. I would be happy to.

Mr. ROE. I know that both the gentleman from California and the gentleman from Florida are going to generate another series of questions, but I just want to—if I can intrude on that dialog.

The one thing I'm thinking about is the relationship of reusable parts as it relates to spare parts, as it relates to testing, which they're going to get into next. I think that becomes very important because of metal fatigue and so forth and so on. I don't know whether you want to start that or whether——

Mr. PACKARD. Let me just ask two short questions before we get into that, Mr. Chairman.

I'm interested in the putty because it's a part of this failed joint, and I want to make sure there's not any portion of that joint that we leave unattended in this hearing.

The putty is placed in Utah, Brigham City, UT; it is much colder there. It is a much different climate, different atmosphere and altitude and so forth. Have you, in our review and any tests or research, found that the putty acts differently at the factory there in Utah compared to there at the cape?

Mr. THOMAS. Yes, sir, the putty will react differently at different temperatures.

Mr. PACKARD. In what way?

Mr. THOMAS. It will become more dense at cooler temperatures and lower humidity than it does at warmer temperatures and higher humidity.

Mr. PACKARD. Now, is the testing generally done in Utah on that joint?

Mr. THOMAS. Yes, it is.

Mr. PACKARD. So the putty is tested in Utah?

Mr. THOMAS. Right.

Mr. PACKARD. Have there been any efforts to test the putty and its function, the way it functions, whether it meets the design specs at the cape?

Mr. THOMAS. Yes. We have taken, during the investigation—taken the putty and conditioned it to the conditions that one would expect at KSC, and the conditions that one expects at Brigham City, UT and tested those and compared the results. We were using 80 percent relative humidity at 75 degrees and 10 hours for the conditioning of KSC putty and slightly less than that for Utah putty. We have not been, however, able to create—or produce—enough tests to create a trend that one is significantly worse than the other.

Mr. PACKARD. Well, at the factory—in your factory joints, obviously, the putty has remained much more—the integrity of that joint and the putty has been much more successful than it has at the field joints, where they have to put the putty in there at the cape.

Mr. THOMAS. Mr. Packard, there is no——

Mr. PACKARD. But tests have not shown where there has been any—well, maybe I have misunderstood that process.

Mr. THOMAS. There is no putty in the factory joints.

Mr. PACKARD. There is not?

Mr. ROE. Will the gentleman yield for a minute?

I think it might be helpful to your question on the putty, and help the committee, in the following way if I may.

There is some dialog going around, as the gentleman from California is pointing out, in reference to the putty issue itself per se, that originally—purportedly—NASA used one particular manufacturer of a particular type of putty which uses asbestos as part of the base, as I understand it. That company purportedly went out of business or wasn't going to make the putty any more, and another company was selected to do that. And there was a question as to whether or not the same formula was identical in the same putty issue.

Could you give us—the gentleman from California is here, and we think it's important to get it on the record—could you give us just a little background and a rundown on the putty issue? Because I think that bears upon what the gentleman is speaking to from California.

Mr. THOMAS. Yes, sir.

Mr. ROE. What factually happened there?

Mr. THOMAS. Your scenario that you just stated is correct in that the original supplier of the putty, which was a—I'm trying to recall the trade name for it—anyway, it was an asbestos-field vacuum putty that was—Fuller-O'Brien, I believe, is the name of it. They went out of—or they stopped making putty, and the putty that the—the new vendor for the putty, although it is asbestos-field as was the other, it is made by Randolph. And it has essentially the same consistency. It reacts a little bit more to humidity; that is, it gets a little less dense or a little bit less viscous with higher humidities, but it essentially serves the same purpose.

Mr. ROE. Then to finalize this point——

Mr. VOLKMER. Will the gentleman yield? The gentleman from California?

Mr. PACKARD. Yes, I'd be happy to yield.

Mr. VOLKMER. I would like to know, were any viscosity tests ever run on the putty at higher temperatures, or temperatures at the interior of the SRB, during firing?

Mr. THOMAS. We have run viscosity of the putty at varying levels of temperatures, but I don't believe we ran it up that high.

Mr. VOLKMER. I mean, the putty is subject to those temperatures when the SRB is being fired, is it not?

Mr. THOMAS. Initially, at the very end of the putty path between the two motors, initially there is the high heat rate. It will erode back with the propellant as it comes back toward the joint, but at the time that the propellant stops burning and then progresses up the bore, it becomes relatively cool.

Mr. VOLKMER. Well, you still didn't answer my question. Does the putty—is the putty subject to that temperature of the inside while the SRB is being fired?

Mr. THOMAS. It is subjected to that temperature.

Mr. VOLKMER. I know for a relatively short period of time, but it is subject to that temperature?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. And we don't know what the viscosity of it is at those temperatures?

Mr. THOMAS. Well, I think at those elevated temperatures, the putty just chars along with the propellant as it goes back.

Mr. VOLKMER. It chars?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. Do you know if it gets real runny, almost like real soft butter, anything like that?

Mr. THOMAS. No, sir, we don't believe it does because it stays a relatively cool temperature a short distance from the burning surface because it dissipates its heat back into the insulation. I can provide that for the record.

Mr. PACKARD. Let me reclaim my time and just ask a question and conclude this item on the putty.

Were any tests run on the putty before the accident?

Mr. THOMAS. Yes, sir, there were a series of tests run at the time that this transition took place from the Fuller-O'Brien to the Randolph putty.

Mr. PACKARD. And does—do we know the difference between the reaction of the putty when its being tested in the horizontal in Utah versus how it reacts at the launch pad?

Mr. THOMAS. I think it—I can't say that we've tested that specifically in the large motor. We have tested it in the small motor during the investigation, although we have—in the static motor tests at Utah, the putty has been examined from the inside to determine its characteristics. It has been repaired a number of times prior to test, and from that standpoint we understand its characteristics.

Mr. PACKARD. My perception is that perhaps NASA would do well to be more familiar with the actual formula for putty and how it operates. We may be leaving that to the manufacturers and to the contractors without us being fully familiar, and I can understand that, because we're certainly not.

One last question, Mr. Chairman. It's bothered me for the last 2 days; in fact, since we were down there and I saw the pictures of the launch pad, for the first time today I came to realize that pad B was used for the first time with 51-L, and I wasn't aware of that. And that means, then, that the failure of the freeze plan happened on the very first usage of the pad, and the water system.

Would you have launched—the decisionmakers for go or no go—would you have launched had the rains fallen and created the amount of ice, both in the joint and on the pad, to the same extent that the failure of the sprinkling system created? Would you have had a decision to launch had you had rain that would have caused those same kind of icicles and the same kind of water problems and ice problems in the joint as the sprinkling system did? That's a hypothetical question, but I think it's interesting.

Mr. UTSMAN. Well, I guess from the viewpoint—the analysis—let's take the ice on the fixed service structure and that. I think the analysis would have indicated, because the source of the icicles would have been the same, and so from that basis the decision would have been the same from that aspect.

As far as water in the joint, we did not know of the phenomena of water in the joint until after, as part of the investigation. And so I'm not sure I know what we would have done in that case. There may have been many other factors, though, on a cold night, raining like that, that would have much precluded that.

Mr. PACKARD. Well, I think you have seen the picture, of course, that we've seen in the report. And as you look at it, it becomes incredible that we would feel inclined to launch with that kind of environment.

In our briefing on Friday at the cape, one obvious way to prevent water—and thus ice—into the joint, which I think the Commission's report certainly indicates had a profound effect upon the resiliency of those O-rings—in fact, the report says that, perhaps not contrary to Admiral Truly's comment that the cold weather had more adverse effects than the ice and the water did, but at any rate, this report says that the ice did displace the O-rings, that it actually displaced them, which had an effect upon the ultimate seal.

Simply turning that seal over, reversing it so that it does not point upward—thus water and ice flowing down into that joint—would appear to be a simple way, although probably a costly way now to redesign. But certainly, it is an open trough; that clevis points upward; that allows the water to flow right down around the tang fitting into the clevis. But we're not in the redesign business, but certainly that ice and water can easily be prevented from entering into that.

Admiral TRULY. Mr. Packard, you are exactly right. I think that probably, at this stage, would be a very costly fix, but I can assure you that the redesign fix will not allow water into that joint.

Mr. PACKARD. Mr. Chairman, I will yield back my time.

Mr. ROE. One of our colleagues suggested to the distinguished gentleman from California, praise be to the Lord to see a spaceship designed by the Congress. [Laughter.]

The Chair recognizes the distinguished lady from Tennessee.

Mrs. LLOYD. I thank the Chairman.

Mr. Chairman, we've been talking about safety throughout our hearings. I really think another thing we might revisit is how well we do manage risks, because certainly this determination has to be made on every flight.

The Washington Post had a very descriptive diagram, if you didn't see it, an article on May 25 that really gives us a very succinct description of the steps that are used to determine your risk management program. I'd like for Dr. Fletcher if you would, or someone else if you might like to just defer to someone else, to describe the elements of NASA's risk management activities, what really supports your risk management decisions.

Dr. FLETCHER. Well, I will start, Mrs. Lloyd, but risk management is a pretty generic term. Risk management is decided in headquarters in terms of what are the chances of an overall failure of the system under a given set of circumstances. When you get down to the flight team, the launch crew in those last several hours or couple of days, risk management is an entirely different thing. They have to look at the factors that have come up just before launch and assess whether this is a risk we want to take. This is a judgment question; you can't make calculations at this point.

Mrs. LLOYD. Well, I realize that on the day of the launch that might be the case, but Dr. Fletcher, I do think there are procedures and methods that are used to assess risk. I think Dr. Silveira testified before my subcommittee as well as Mr. Nelson's at a joint hearing last March on this subject, and if you would like me to speak to Dr. Silveira to address this question, it would be fine with me.

Dr. FLETCHER. Yes, I guess so.

Dr. SILVEIRA. As we had mentioned in the testimony that we had given previously to yourself and Mr. Nelson, the only time that we had gone into trying to assess a probability, if you will, or a risk, was as a result of a request that was made by DOE for their analysis that they were performing at that time, to assess the probability of failure of the vehicle, to assess the danger when we are flying the RTG's, the radioactive material.

As far as in our program and any major decisions that we would make, we have a number of reasons why our past history had indicated that that was not a good way of doing it. As a result, we don't use it generally in our risk management. We prefer using things like the failure effects and analysis that we do; the technical engineering judgment, using things to control our failures rather than depending on a probability analysis to assess it.

Mrs. LLOYD. But basically, what do you do beyond the failure modes and effects analysis, Dr. Silveira?

Dr. SILVEIRA. Yes, ma'am. Any time, of course, that we do have a failure component, and we track these very carefully from our ground test program as well as our flight test program, we go back and make sure we thoroughly understand that failure and, of course, effect a redesign to ensure that that failure will not repeat itself.

Mrs. LLOYD. And you test the components at that time?

Dr. SILVEIRA. Yes, ma'am.

Mrs. LLOYD. Dr. Silveira, what was the basis for NASA's assigning a probability of 1 in 100,000 to a catastrophic SRB failure?

Dr. SILVEIRA. Well, as I say, as a result of a request from DOE to assess a number, we went back and attempted to look at various parts of the vehicle, various systems to establish a probability of failure of those particular components. When that was added to a statistical analysis—and indeed, a lot of these things don't lend themselves to statistical analysis; for instance, as I say, every time you have a failure you repair it, so you destroy your data base and you really don't have a good data base to go against. So as a result of trying to come up with these numbers for use in the safety analysis, our people developed numbers, went back and combined them, and then came out with a number that said it would be more like 10 to the minus 5 in our analysis, 1 in 100,000 cases.

Now, there are verbs that were in the shuttle data book that was the official transmission of that data, which I think that we had provided the staff earlier to look at, which said that indeed that was a case where a failure would be highly unlikely, that it was remote to happen.

Mrs. LLOYD. Well, yesterday, if you remember, reference was made to the report by Teledyne and Sandia and the Wiggins Co.——

Dr. SILVEIRA. Yes, ma'am.

Mrs. LLOYD [continuing]. And this claimed that the probability number would be somewhere between 1 in 34 to 1 in 10,000. So I just wanted you to explain this discrepancy for the record, Dr. Silveira.

Dr. SILVEIRA. Yes, ma'am. As you recall, back in about the 1977 time period NASA had commissioned the Wiggins Group to go and conduct a study for range safety purposes. Now, at that time we weren't looking at the vehicle with a Centaur vehicle on board and the like. And their analysis went back and looked at all the statistical data of all vehicles at that time and said that the probability of failure was like 1 in 57, in that order. Of course, we said that's like comparing apples, oranges, and things like that; there are a lot of vehicles in that family that don't relate to our vehicle. We think we're somewhat unique, both in the way that we operate and in some of the redundancy that we've provided and increased safety factors that we've provided in our design. And as a result, we felt that that study was not proper. Since that time, the Air Force has conducted additional studies with the Wiggins Group, that is now another group, plus Sandia and other people to try to assess what they would figure—using, again, the statistical data base from previous experience with solid motors—and come up with a number that they had.

Where we left the study, their statistical numbers would come out like about 1 in 100. They said, we think it's really better for the reasons of more conservatism in the design and the like; they said it would be about 1 in 1,000. We said we still adhere to our number because we think a failure is highly improbable in the shuttle. We agreed that we would plug in the range of numbers, their 1 in 1,000 and our 1 in 100,000, and see how that would affect the end numbers as far as the safety as far as flying the radioactive material. And that was about the place we were headed at that time.

Mrs. LLOYD. Well, do you intend to revisit this decision? I certainly think we should make the very best risk management analysis that we could.

Dr. SILVEIRA. Yes, ma'am. Of course, we're going back and looking particularly at the "Challenger" tragedy to look at yields, how the vehicle failed; as you recall, another big discussion that we were having with the people that were reviewing us was the matter of how the vehicle broke up and the forward bulkhead analysis and——

Mrs. LLOYD. Well, are you looking at a statistical data base? It might really help you in your analysis.

Dr. SILVEIRA. Well, of course we will go back and look at whether there is anything else we can pull out there. But of course, we will still have a hard time in changing our statistical data base from anything we know as far as the *Challenger* is concerned right now.

Mrs. LLOYD. Well, could you establish a data base?

Dr. SILVEIRA. As far as probability of occurrence?

Mrs. LLOYD. That's right.

Dr. SILVEIRA. I think we would still have a hard time doing that and saying that we were going to use it for any management decision.

Mrs. LLOYD. Well, it would be an expensive project.

Dr. SILVEIRA. Well, if you mean go back and do testing on the thing——

Mrs. LLOYD. That's what I mean.

Dr. SILVEIRA. As we had in the shuttle data handbook, if we performed a certain function a thousand times, the only thing that we would—and did it successfully, tested a thousand times successfully—that would only give us a confidence factor that we would possibly have three failures in the next thousand events, with a 95-percent confidence factor. So we don't think that we could do that much testing. Of course, as soon as we saw any anomaly in that testing, we would go back, redesign, try to fix it, and then you'd have to reestablish your data base and start testing again.

Mrs. LLOYD. Well, it didn't work for the *Challenger,* and I feel that this is an area where we need to really revisit and look at it again.

Dr. SILVEIRA. Yes; ma'am.

Mrs. LLOYD. Thank you very much.

Thank you, Mr. Chairman.

Mr. ROE. I thank the gentlelady from Tennessee.

The gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Let me say first of all, I admire the stamina of all of you, sitting there and so on for all this time and so on. You've done a remarkable job of testifying and so on, but you've also shown great stamina.

Let me ask just a couple of questions about whether or not you now see, as a result of the investigations done by your technical people, and also as a result of the Commission report, whether you now see changes in what you are going to do in flight rules. That may not be the best term, and that may not be a precise term, but I'm thinking about—you obviously are not going to fly in low temperatures now. You now know that very low temperatures are probably a reason not to fly on a particular day. There were other things that caused you not to fly in the past; if you had wet weather, for instance, you didn't fly because of the possible problem with the tiles.

Have you now developed another set of things growing out of the *Challenger* incident that will give you new points of departure each time that you fly, things that you will decide not to fly?

Admiral TRULY. As a result of the accident—and one of the things that I directed be done—was a complete reassessment of mission rules in the launch and abort mission phases, and the Mission Operations Directorate at Houston has taken that chore. Frankly, in the things that we're doing—No. 1, they're not through; they've not finished that, and if any specific mission rule changes have made to this point, I'm not aware of them. But I intend to review their work.

On your point about cold weather, I think there's certainly going to be an emotional reason not to launch in cold weather. I would put it a different way. We're going to make sure that whatever weather we launch in, be it temperature or environment—or clouds is one that we're totally confident that we have certified and tested to, and there is no doubt in anybody's mind, whether it be level 4, 3, 2, or 1, that we're ready to launch, no matter what the temperature is.

Mr. WALKER. Would it be helpful if this committee were to help you get a doppler radar at the Cape for better local forecasting?

Mr. ROE. Don't kick the gift horse in the face.

Dr. FLETCHER. I wish I was the one that is doing the weather analysis. Could I get Mr. Aldrich to come to the microphone if he's here, and answer that question and tell you where we are on our attempt to upgrade weather forecasting capability?

Mr. WALKER. Sure.

Mr. ALDRICH. Mr. Walker, we've been discussing doppler radar systems for better real-time understanding of the upper level winds for some time. And as I answered Mr. Nelson's question yesterday, we intend to pursue those systems for direct application for that use. My understanding so far is that it will be even more useful for the kind of upper level winds that we regularly see at Vandenberg than for Florida, and we have approved recently, with the Air Force, a test program of a doppler radar there. We are very encouraged that these will add to our capability, and certainly, we would be appreciative of support in providing these systems, as we can understand what they will contribute to our overall system.

Mr. WALKER. As I understand it, they would at least provide us with a better handle on wind shear; is that correct?

Mr. ALDRICH. We need to test to be sure we understand what they will tell us, and it's very promising and hopeful that they will, yes, sir.

Mr. WALKER. And when I talk about flight rules, the one thing that concerns me, having viewed your time line, and I raised a question briefly this morning on it, is that it appears as though the launch of 51-L—that at the time the maximum dynamics were on the craft, it was also a period of time when it was experiencing a wind shear problem, a fairly strong wind shear problem.

Will we be reviewing a pattern of not launching if we have reason to believe that we have significant wind shear at altitudes where the ship would be undergoing its most massive loads?

Dr. FLETCHER. Mr. Walker, as you know, we've always had launch rules which depend on wind shear at altitudes. What we're talking about with a doppler radar is having a better fix on that wind shear. We mostly have estimated wind shear from the magnitude of the winds and so forth, and estimated the wind shear. Measurement precisely will, of course, be improved somewhat by doppler radar, and I imagine that's what we're talking about. We have to really test and see how much better that is before we implement a doppler radar system.

Mr. WALKER. Well, I really do think that the wind shear question becomes an important one, at least in my mind. For example, have you correlated the winds aloft on 51-C with the winds aloft on 51-L, since 51-C is where I understand we also had fairly significant O-ring problem? Has that, as a contributory problem, been correlated at this point?

Mr. THOMAS. Yes; sir, we have correlated the—not specifically; I don't recall whether we did 51-C or not, but we looked backward to see if we could see any correlation that would show that this one was worse than any of the previous flights, and we selected the worst previous flight to compare. And unfortunately, I don't remember which one that was, whether it was 51-C or not.

Mr. WALKER. OK. When you went back and looked, did you find that on the two flights you had a fairly similar wind shear problem at the time that the load design on the ship was the greatest?

Mr. THOMAS. I don't recall that, Mr. Walker, I'm sorry, whether we did that or not. I would have to review the data. I just don't recall.

Mr. WALKER. I would appreciate if you would, letting us know on that, and getting back to us, because it seems to me that the fact that you had the initial failure that you see in the black puff of smoke, then the resealing, and then the understanding, now, that at the point that the ship was under the greatest dynamic stress loads, that it then failed a second time, or the failure became catastrophic, that it may well be that the winds also contributed to that particular problem and it would be, I think, very advantageous to know whether or not there is a correlation to past failures because it would certainly play a role, it seems to me, in some design conditions if we're finding that the buffeting of that ship by winds has a role to play. And it certainly would seem to me that

that then becomes a question on launch rules. Does that all seem logical?

Admiral TRULY. Mr. Aldrich would like to add a comment to that. He is very familiar with what happened on 51-L with the wind shears, and I think it would help you resolve this issue.

Mr. ALDRICH. All of these conditions we've discussed with 51-L were the result of a major cold front that came down from the central part of the country across Florida, and the conditions on launch day were the temperatures and the final winds at the back of that front.

The system we use currently involves balloon launches and some very elaborate calculations to try to predict the winds based on the conditions we know and see, and I think your point is well made, that there were some unique weather-related shear conditions here, potentially, that could not be predicted through those approaches. And we are certainly reviewing that, both in terms of other indicators that we might have had that would be in addition to the doppler weather, and in terms of changes and more conservatism in the rules for those kinds of weather patterns. And I think yes, all of those points are well made, and we are and will be looking at those.

Mr. WALKER. So that what you'll end up doing is establishing some different weather parameters for the launch director to use in making his decision, and they'll be more conservative than those you have used in the past; is that what you're saying?

Mr. ALDRICH. We will be looking at doing that, yes. I understand the weather community now assesses the general conditions to indicate a higher potential for shear, and we were in fact dealing with what our balloons and our calculations on that day—and you can't prove what was there at the exact time of the launch, but you can postulate that shears could have been more prevalent or more significant than what was expected.

Mr. WALKER. I thank the chairman.

Mr. ROE. I thank the gentleman from Pennsylvania.

The gentleman from Missouri, Mr. Volkmer.

Mr. VOLKMER. Thank you very much, Mr. Chairman.

I have several areas. First is a technical one. Can you tell me how it's possible to maintain a tolerance of plus five thousandths and minus three thousandths on a piece of rubber roughly one-fourth inch in diameter and 37 feet long?

Mr. THOMAS. The process is that the O-ring is formed, and then it is ground with precision instruments to that diameter. It is actually ground that way.

Mr. VOLKMER. All right. Now, at what temperature is it ground?

Mr. THOMAS. Ambient temperature.

Mr. VOLKMER. In the plant or factory, wherever it's done?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. And that could be 75 degrees or 80 degrees or 60 degrees? Somewhere in that area; I'm sure that they don't work when its too cold. And we do know, as I asked down at Kennedy, we do have some loss in coldness, do we not?

Mr. THOMAS. Yes, sir; we do.

Mr. VOLKMER. And doesn't that then affect the amount of tolerance?

Mr. THOMAS. When we compute the squeeze—computed the squeeze numbers on 51-L, we took into account the differential coefficient of expansion of the rubber down to the lower temperature. And as I recall, that amounted to approximately three thousandths of an inch on the diameter.

Mr. VOLKMER. Now, is that three thousandths of an inch additional smaller in diameter? That's three thousandths smaller than it was in the factory?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. Now, if it was already down three thousandths because of the tolerances permitted, then you're three thousandths under, are you not?

Mr. THOMAS. When we compute squeeze on the O-ring, we use the minimum specification diameter, which is three thousandths less, or 0.277 O-ring, so it would be three thousandths below the 0.277.

Mr. VOLKMER. But if it came out of the factory with three thousandths less——

Mr. THOMAS. We assume that it does that in any case. We assume, in computing squeeze, that it is of a minimum diameter.

Mr. VOLKMER. All right. But what I'm trying to get out, the cold also reduces it three thousandths in addition?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. So now you're actually under the specifications, the tolerance level?

Mr. THOMAS. Maybe I should explain that the minimum O-ring squeeze is 7.5 percent of the diameter. And in order to assure that we have that, we take all of the worst case dimensions for the as-machined configuration of the metal and the minimum specification number for the O-ring, and then be sure that the shim that is installed into the clevis produces more squeeze on the O-ring than the minimum. And on 51-L, we still met the minimum squeeze condition with the 0.277 presumed O-ring and the three thousandths shrinkage due to temperature.

Mr. VOLKMER. All right.

To continue on with the O-ring, on page 158 of the Presidential Commission report, there is a document known as the SRB Critical Items List. On this it says, "A more detailed description of SRM joint testing history is contained in TWR-13520, Revision A." Have you all reviewed that, that testing history?

Mr. THOMAS. I'm sorry, sir. I don't recall which one that is. That, I believe, is attached to the Critical Item List revision of about a year ago. I don't recall——

Mr. VOLKMER. More than a year ago, because this document is dated December 17, 1982, so it has to be prior to 1982.

I'd like you to furnish us a copy of that document.

Mr. THOMAS. Yes, sir.

Dr. FLETCHER. We will do so, Mr. Volkmer.

[Material to be supplied follows:]

Material requested for the record on page 201, line 4926, by Mr. Volkmer during the June 12, 1986, hearing.

A copy of the requested document TWR-13520, REV. A is attached.

DOC NO. TWR-13520 VOL REV A

TITLE

RETENTION RATIONALE, SRM SIMPLEX SEAL

Howard H. McIntosh

Prepared by

Howard McIntosh

Rel - J Tibbitts

1 December 1982

Thiokol / WASATCH DIVISION

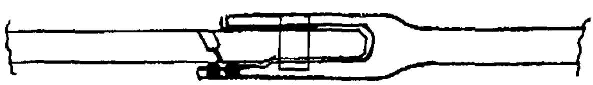
A DIVISION OF THIOKOL CORPORATION

P.O. Box 524, Brigham City, Utah 84302 801/863-3511

1

RETENTION RATIONALE, SRM SIMPLEX SEAL

The SRM steel case joint design is common to the regular weight case and the lightweight case. All dimensions are the same and the assemblies are identical, including the shimming after assembly. The joint is basically a modification of the single O-ring Titan tang and clevis joint with the same tolerances, but allowing more clevis gap for horizontal assembly. A second O-ring provides a leak check test to be made, between O-rings, to verify the O-ring seal after assembly. Shims are used between the clevis outer leg and the tang to obtain the maximum amount of O-ring squeeze for sealing.



This report contains a summary of numerous tests and uses of the SRM joint to provide the rationale for the retention of the simplex seal. Total experience to date includes:

a. Similar joints
b. Leak checks at joint assembly
c. Hydrotests
d. Hydrobursts
e. Static motor firings
f. Motor flights
g. Laboratory bench tests

Experience has shown positive functioning of the primary O-ring in all instances of use in the SRM tang and clevis joint. Testing has indicated positive sealing under adverse conditions beyond the required single pressurization for motor operation. It is concluded that considering the SRM joint as a single O-ring seal, sufficient rational exists to retain this design with assurance of performance. A data base is also being established in support of the secondary O-ring positive sealing.

A. Similar Joint Use

1. The Titan case joint contains a single O-ring bore seal. The tang-clevis-pin joint design of the SRM uses the same design

tolerances as this well proven joint. Titan joints have a record of over 1100 joint use data points during the testing and throughout its flights with no loss of pressure. The SRM joint differences include: Increased clevis gap for horizontal assembly, second O-ring added to verify single O-ring presence and uniform shimming to center tang and close the clevis gap.

2. Initial assemblies of SRM joints contained no shims and all routine hydrotests are conducted without shims.

B. Leak Checks (Over-all total of 930)

1. All new segments have leak checks before hydrotest on all tangs and clevises. No leaks experienced.

    a. Increment I 28 domes + 2x122 segments = 272 tests

    b. Increment II 12 domes + 2x73 segments = 158 tests

    Total 430 tests

    Note: Vertical assembly
    no leaks experienced

2. All plant joints have leak checks on case fabrication assembly and refurbishment proof test (in casting segment configuration). Vertical.

    a. Fabrication of 8 static tests - 56
    14 flight cases - 98
    4 GTM + STA-1 - 31
    TOTAL 185

    Two leakers experienced and debris found as cause

    b. Refurbishment hydroproof of
    7 static tests - 49
    26 GTMs - 14
    6 Flight Cases - 42
    TOTAL 105 plant joint

    No leakers experienced. (One stiffener to stiffener joint leak upon depressurization).

3. Field joints are tested horizontally at Thiokol for static firings only. All other leak checks are conducted with vertical assembly.

    a. Static tests 8 x 3 = 24 checks
    Repeats = 8 minimum

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Four leakers experienced with 2 on DM-1 and one each on DM-3 and DM-5. No leaks after reassembly.

b. CTMs were assembled at MSFC and KSC

4 x 2 x 3 = 24 checks

c. Flight checks at KSC 5 x 3 x 2 = 30 checks

extra 1 = 1

Total 31

One leaker experienced and debris identified.

d. Refurbishment hydrotest 17 x 6 = 102 checks

4. Extra checks on hydroburst, joint verification and STA-1 efforts produced approximately 20 checks with no leakers on first cycle joints.

C. Hydrotests at Rohr, Thiokol and MSFC have been conducted at pressures above 1037 psig with no leakers.

1. At Rohr 150 + 85 = 235 tests on segments

2. At Thiokol 17x4 = 68 tests

Extra = 3

71 Tests

No leakers experienced upon or at pressure. (One stiffener to stiffener joint leaked upon depressurization).

3. MSFC tests on STA-1 pressurization with new O-rings produced no leaks even after 4 pressure cycles (experienced O-ring "pinching" during depressurization and nibbling after cycling).

D. Hydrobursts -

1. Regular weight case joints were cycled with proof pressurizations and experienced leakage past the "nibbled" primary O-ring after eight cycles. After twenty cycles, the O-rings were replaced and maximum design pressurization was achieved (1.4 safety factor) however leakage past the rotated joint O-rings occurred at high pressures (1,480 psig or 1.58 x MEOP).

2. Lightweight case joints passed all tests which included four cycles to MEOP (one with a planned defective primary O-ring) and an 1.4 MEOP pressurization. The joints were then sealed on the inside with vulcanized rubber to enable the burst to take place at 1550 psig.

E. Static Motor Firings

No joint leaks have been experienced during eight horizontal static motor firings. Adverse conditions of joint movement from a "sagged" position to flight position upon pressurization were experienced without joint leakage. A pressure reading, taken on each test, between the O-rings of the center field joint, showed variations in pressure traceable to joint movement (from vacuum to pressure above ambient).

F. Five Shuttle flights have flown involving ten SRM cases with no evidence of a pressure leak past the primary O-ring of the joints.

G. Laboratory Bench Tests.

1. High pressure extrusion tests have shown pressure retention of a standard .280 in. dia. O-ring in a gap of 0.125 in. at 1600 psi.
2. Low pressure check with the sealing surface defects testing device show remarkable sealing power of the single O-ring with large, deep and rough surface defects using minimum squeeze.

REDUNDANT SEAL DATA BASE - In order to establish a redundant seal data base, additional data are being obtained on all refurbishment hydrotests by checking the actual joint movement due to pressurization with a direct reading dial indicator through the pressure port. Initial information generated in a lighweight cylinder to cylinder proof test shows a total movement of only .030 in. at 1004 psig in the centerjoint (dial indicator in tang against land between O-ring grooves on the clevis inner leg). This test conducted in the normal vertical mode, indicates that the tang to clevis movement will not unseat the secondary O-ring at operating pressures. This one point data base will be up to ten points after DM-5 and STS-5 cases have been refurbished.

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Mr. VOLKMER. Specifically, I'd like to have a copy of it.

I know we have a vote going on. I have several more questions.

To get into the question of temperature, what is more important, ambient or air temperature, or the temperature at the joint?

Mr. THOMAS. The temperature at the joint.

Mr. VOLKMER. Then why don't we, when we make a determination of whether we meet criteria in order to launch, require certain temperatures to joint?

Mr. THOMAS. That should have been a mission rule.

Mr. VOLKMER. It should be in the future?

Mr. THOMAS. Yes, sir.

Mr. VOLKMER. Now, does the—earlier we had testimony, yesterday, about the 31 °F temperature for the SRB itself. That only related to, as I understand it, to the total SRB or the ambient temperature at the time of the launch. Is that correct?

Mr. THOMAS. Let me ask Mr. Lee to respond to that. I'm not aware of it.

Mr. LEE. That is the natural environment, outside temperature, if you will, the 31 to 99 degrees. That's right.

Mr. VOLKMER. Right. That's the—so yesterday, when I asked a question on what the temperature was at time of launch, that was 36 degrees, that's the outside temperature also?

Mr. LEE. Yes, sir.

Mr. VOLKMER. That does not relate necessarily to the temperature of any part of the SRB, including the joints?

Mr. LEE. That's true.

Mr. VOLKMER. And as I guess we found out, it's more important to worry about the temperature of the SRB and joint temperature and other things, is that not correct?

Mr. LEE. Absolutely.

Mr. VOLKMER. Now, I'd like to ask anyone who wants to answer this question, if you want to do so——

Mr. ROE. Would the gentleman yield?

Is anyone planning on voting?

Mr. VOLKMER. Well, I'd like to.

Mr. ROE. Well, we're on the second call. Why don't you and I vote and come back again?

Mr. VOLKMER. OK, fine.

Mr. ROE. Why don't we suspend for about 10 minutes? We'll be right back. We should finish up in about 20 minutes.

[Recess.]

Mr. ROE. We will reopen this hearing for only a short period. We've just learned that there will be at least two to three more votes, and they're imminent. I've talked to Mr. Nelson and Mr. Volkmer, and we've agreed that we do have some additional questions but we will put those in writing and forward them to you. And should there be an occasion that we think we need additional personal testimony, then we'll be back in touch with you to see what we can work out.

Mr. ROE. Meantime, on behalf of the committee, I want to—and I know you have an observation you'd like to make, Dr. Fletcher, so if you would proceed.

Dr. FLETCHER. Mr. Chairman, I'd like for the record to personally express our sincere thanks from all of NASA to Princeton University for making J.R. Thompson available to the task force for these past months. I recognize the importance of his position at Princeton, and I'm sure his availability to us was not without significant impact to his work at Princeton. As you know, he's deputy director of the Tokomak Program down there. NASA and the Nation should be grateful; and I might add, I appreciate your forbearance, Mr. Chairman, for all of us in answering your questions.

Mr. ROE. Well, I appreciate that. And on behalf of myself and the committee, I want to thank you, Dr. Fletcher and Admiral Truly and Dr. Thompson and all of the other distinguished representatives of NASA that have testified over the last 2 days. I think your contribution to the record and your contribution to educating members of the committee and providing the substantive information in candor and right up front was what was necessary at this point of our proceedings. So we want to thank you for your patience, your forbearance, and your indulgence. It's been very productive.

Now, for the benefit of the other members that are here and the staff people, we will now, in effect, adjourn today, but we will reconvene on Tuesday at 9:30, and our first witnesses up will be Thiokol. And then we're going to have in the afternoon the representatives from your Marshall Space Center. So that is what our schedule is.

Again, many thanks. We appreciate it. The hearing stands adjourned.

[Whereupon, at 5:02 p.m., the committee recessed, to reconvene at 9:30 a.m. Tuesday, June 17, 1986.]

INVESTIGATION OF THE CHALLENGER ACCIDENT

(Volume 1)

TUESDAY, JUNE 17, 1986

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC.

The committee met, pursuant to call, at 9:30 a.m., in room 2318 Rayburn House Office Building, Hon. Robert A. Roe (acting chairman of the committee) presiding.

Mr. ROE. The committee will come to order.

We begin our second week of hearings in the Science Committee's investigation of the shuttle *Challenger* accident.

In following our schedule, this morning we will hear from witnesses from Morton Thiokol, the designer/manufacturer of the solid rocket booster's motor joint.

The design and functioning of this joint has been identified by the Rogers Commission as the prime cause for the shuttle's failure on January 28.

Charles Locke, chairman of the board and chief executive officer of Morton Thiokol will be accompanied by Edwin Garrison, president of the Aerospace Group; Joseph Kilminster, vice president; Carver Kennedy, vice president of the Space Booster Programs; Allan McDonald, director of the SRM Verification Task Force; Roger Boisjoly, staff engineer; and Arnold R. Thompson, supervisor of structures design.

This afternoon we will hear from Marshall Space Flight Center personnel. The committee considered it extremely important that we juxtapose the appearance of the Morton Thiokol witnesses with those from Marshall because it is this center that has the safety oversight responsibility for NASA's SRB Program.

The aerospace contractors have a major role and responsibility in the development of our Nation's space programs. The relationship between NASA and these contractors is a critical element in how these responsibilities are fulfilled.

We are anxious to hear from and to question this morning's witnesses. There is much ground to cover in a limited amount of time, so gentlemen, welcome.

I have a few other comments I want to make for the benefit of the members, but I will defer to our distinguished ranking member, Mr. Lujan from New Mexico.

Mr. LUJAN. Thank you very much, Mr. Chairman.

I, too, want to take this opportunity to welcome today's witnesses to our committee's investigation of the *Challenger* accident and to thank them for their appearance before us.

I believe that what we hear from them will be of critical importance in our search for the chain of events which led to the *Challenger* accident.

I encourage our witnesses to lend us a willing hand in determining the precise history of the field joint, the reaction of corporate management to design and operating problems as they became apparent, and the responses of the Marshall Space Flight Center to those problems.

It is important for us to determine to what extent NASA, including its field centers and its contractors, understood the problems of the solid rocket booster joint.

Both the Marshall Space Flight Center and personnel at Morton Thiokol will be afforded the opportunity to participate in a fair and open review of the facts today.

As this committee conducts its investigation, it is imperative that we determine who said what to whom, when, and where, and what was then done about specific problems relating to the joint. And we must understand exactly what went wrong in the chain of communications between the contractor for the solid rocket booster and NASA.

For my part, I want to understand how key personnel executed their responsibilities. All of us need to understand whether we are dealing with a compound failure in implementing a highly complex management system or whether the system itself is, in the words of the Rogers Commission, flawed.

Further, I am deeply concerned by an apparent failure in the certification process. NASA believed that the SRB was certified for flight temperatures of 21 degrees Fahrenheit, and apparently it was not. During the course of our hearings we will find out how much of this was due to contractual ambiguities, misinterpretation, a failure of the contractor and/or a failure of NASA to monitor the contractor properly. Our investigation will not be complete until we have the answers to these questions.

Thank you very much, Mr. Chairman.

Mr. Roe. I thank the distinguished gentleman from New Mexico.

[The prepared opening statement of Mrs. Lloyd follows:]

STATEMENT

HON. MARILYN LLOYD

JUNE 1~~9~~7, 1986

WITNESSES

MORTON THIOKOL

MARSHALL SPACE FLIGHT CENTER

MR. CHAIRMAN. LAST WEEK THE COMMITTEE HEARD FROM THE ROGERS' COMMISSION AND NASA OFFICIALS ON THE SHUTTLE CHALLENGER ACCIDENT. IT WAS CLEAR TO ME THAT THE MAJOR GOAL FOR THE COMMITTEE WHICH CAME OUT OF THOSE HEARINGS IS THAT WE MUST INSURE THAT NASA CAN FLY SAFELY IN THE FUTURE. IT IS CLEAR TO ME THAT FOR THIS GOAL TO BE ACHIEVED THERE ARE TWO MAJOR REQUIREMENTS: 1) THE SOLID ROCKET BOOSTER (SRB) DESIGN MUST BE FIXED, AND 2) INSTITUTIONAL FIXES MUST BE MADE IN NASA IN TERMS OF RISK MANAGEMENT COMMUNICATIONS AND RELATED DECISIONMAKING. PURSUING THE QUESTION OF INDIVIDUAL CRIMINAL NEGLIGENCE AND RELATED LIABILITY SEEMS TO ME TO SERVE NO USEFUL PURPOSE. IN FACT, SUCH AN APPROACH CAN ONLY SERVE TO DISCOURAGE PROGRAM MANAGERS IN NASA AND AMONG HER CONTRACTORS FROM MAKING HARD DECISIONS IN THE FUTURE. THIS COUNTRY IS ALREADY IN THE THROES OF A LIABILITY CRISIS. I HOPE THAT

NO ONE ON THIS COMMITTEE WILL POISON THE ATMOSPHERE THROUGH PLAYING "WHO SHOT JOHN" IN TERMS OF THE CHALLENGER ACCIDENT AS NASA ATTEMPTS TO TURN THINGS AROUND.

I AM OF THE OPINION THAT SIGNIFICANT CHANGES IN THE MANAGEMENT STYLE THAT HAS CHARACTERIZED NASA'S APPROACH TO DIRECTING THE SHUTTLE PROGRAM ARE REQUIRED IN AT LEAST THREE AREAS.

FIRST, IT SEEMS TO ME THAT SENIOR MANAGEMENT MUST HAVE A BETTER MEANS FOR AUDITING NASA'S OVERALL CONFIGURATION MANAGEMENT SYSTEM AS IT APPLIES TO THE SHUTTLE ACTIVITY. THERE IS A HIGH DEGREE OF TRUST IMPLICIT IN THE MANAGEMENT STYLE AND THAT IS GOOD. HOWEVER, IT SEEMS TO ME THAT LEVEL 1 MANAGERS HAVE VERY LITTLE UNDERSTANDING OF THE DECISIONMAKING PROCESSES THAT GO ON AT THE LEVEL 3 FLIGHT READINESS REVIEWS, FOR EXAMPLE. THEY DEPEND UPON THE FLOW OF INFORMATION BEING ACCURATE AND CONCISE; HOWEVER, IT IS CLEAR THAT EACH CENTER HAS ITS OWN MANAGEMENT STYLE. THUS, IN CERTAIN CASES, COMMUNICATIONS FLOW UPWARDS CAN GET DISTORTED OR MISINTERPRETED VERY EASILY. HEADQUARTERS MUST HAVE A MEANS FOR ASSURING ITSELF THAT THE DECISIONMAKING PROCESS AS IT PROMULGATES THROUGH THE WHOLE CHAIN OF COMMAND FROM THE CONTRACTORS THROUGH THE FIELD CENTERS, PROGRAM MANAGEMENT, AND FINALLY

TO HEADQUARTERS, IS ACCOMPLISHED IN A CLEAR AND CONCISE MANNER. IN THIS WAY, THE CONTROL PROCEDURES, CRITICALITY ISSUES AND ENGINEERING CHANGES SHOULD BE FULLY UNDERSTOOD AT ALL LEVELS AND ANY PROBLEMS THAT ARISE ARE CLEARLY COMMUNICATED TO AND AT ALL LEVELS.

SECONDLY, THE AUTONOMOUS OPERATING STYLE THAT HAS CHARACTERIZED CERTAIN OF THE NASA FIELD CENTERS INVOLVED IN THE SHUTTLE PROGRAM HAS SIGNIFICANTLY REDUCED THE OVERSIGHT CAPABILITIES THAT MUST RESIDE AT THE HIGHEST LEVELS OF NASA MANAGEMENT. THUS, I BELIEVE THAT THE TIME FOR FIELD CENTER DIRECTORS DOMINATING THE DECISIONMAKING PROCESS WITHIN THE AGENCY HAS PASSED, AND IT IS NECESSARY TO STRENGTHEN THE PROGAM MANAGEMENT CAPABILITIES AT HEADQUARTERS.

I HAVE LEARNED, FOR EXAMPLE, THAT A FIELD CENTER SENIOR MANAGER WITH EXTRAORDINARY RESPONSIBILITIES IN THE SHUTTLE PROGRAM RECENTLY VISITED HEADQUARTERS FOR THE FIRST TIME IN NEARLY FIVE YEARS IN ORDER TO PARTICIPATE IN A BRIEFING TO COMMITTEE TASK FORCE STAFF. I AM NOT QUESTIONING THE COMPETENCE OF THIS MANAGER, BUT CLEARLY HIS VISION AS IT RELATES TO THE OVERALL DECISIONMAKING REQUIREMENTS OF THE SHUTTLE PROGRAM MUST BE SIGNIFICANTLY LIMITED. THE FACT THAT SUCH AUTONOMY RESIDES AT ANY ONE LOCATION OUTSIDE OF WASHINGTON DOES NOT DO THE

OVERALL NASA PROGRAM MANAGEMENT STRUCTURE JUSTICE.

THIRDLY, I BELIEVE IT IS ESSENTIAL THAT NASA, ALONG WITH THE CONGRESS, REVIEW AN EARLY SHUTTLE PROGRAM OBJECTIVE TO ENHANCE THE COMMERCIALIZATION POTENTIAL OF THE SHUTTLE BY PERFORMING NEARLY ALL MAJOR SHUTTLE ACTIVITIES THROUGH THE USE OF CONTRACTORS. TODAY I THINK THAT NASA MUST MODIFY THIS APPROACH IN ORDER TO STRENGTHEN ITS IN-HOUSE CAPABILITIES, ESPECIALLY IN THE AREAS OF SAFETY, RELIABILITY AND QUALITY ASSURANCE IN ORDER TO MAKE THE PROCESS WORK.

MR. CHAIRMAN. TODAY WE SHOULD LEARN MORE DETAILS ABOUT THE DEGREE TO WHICH NASA REQUIRES INSTITUTIONAL FIXES IN MANAGING SHUTTLE RISKS. LET US TAKE THESE "LESSONS LEARNED" AS A BASIS FOR OUR FUTURE OVERSIGHT OF NASA'S SPACE TRANSPORTATION SYSTEM. THE WAY IN WHICH THEY IMPLEMENT THESE FIXES WILL DETERMINE WHEN THEY CAN SAFELY FLY AGAIN. IN THAT LIGHT, THIS CAN BE A CONSTRUCTIVE HEARING.

Mr. ROE. Now for the benefit of both our witnesses and our members, let me make the following comments: We will operate today because of the complexities and the in-depth relationship of both groups of witnesses under the 5-minute rule. We will follow that procedure at least until we unfold the basic questions that people want to ask.

I think the second thing I should mention this morning is that in reviewing your testimony, Mr. Locke and your associates and the order of magnitude of the questions that are emerging that I am not sure we can finish everything by noon today, which was our original plan. We are going to try.

The same thing goes with the people from Marshall this afternoon, to try to bring it together.

Why did we select your company and Marshall at this juncture of the hearings? We want to nail down the facts involved in the relationship of what happened in the decision to fly or not to fly. That is what we are trying to ascertain.

The Chair is not interested in the points of view of placing blame at this point. That is not our purpose. Our purpose is to determine exactly what happened, why it happened with the background information to get it on deck so everybody understands that we are not dealing in what may have been. What happened is what we want to know.

The reason for that and why your testimony and the testimony of the representatives from Marshall become important is because we are looking to the second step of our investigation which has to do with management failure or a review that management didn't work in the company or in combination together to help forestall some of the decisions that were made.

That is a key issue that the Commission brought up in their findings and we want to find out what happened and what do we do to not let that happen again.

Mr. SENSENBRENNER. Mr. Chairman, I think that we are getting down to the nubbin of what happened on January 28 and I would request that for this morning's witnesses and this afternoon's witnesses that the Chair place them under oath.

Mr. ROE. Let's take a 5-second break here.

What is the general opinion of the members? I think the gentleman makes a very, very valid point. We could do that for all witnesses. We expect everybody to tell the truth in the first place.

Without objection, I ask unanimous consent that television broadcast, radio broadcast, still photography, and other means of coverage shall be permitted during the full committee hearings on the Rogers Commission report and the investigation of the Science and Technology Committee.

So ordered.

Why don't we have all of the witnesses that are here—we have Mr. McDonald, Mr. Locke, Mr. Garrison, and Mr. Kilminster, and you have who else? Mr. Boisjoly and Mr. Thompson and Mr. Kennedy—all stand, please.

[Witnesses sworn.]

Mr. ROE. I thank the gentleman from Wisconsin for his suggestion.