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SPACE SHUTTLE ACCIDENT

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

ON

SPACE SHUTTLE ACCIDENT AND THE ROGERS COMMISSION REPORT

FEBRUARY 18, JUNE 10 AND 17, 1986

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SPACE SHUTTLE "CHALLENGER" ACCIDENT

TUESDAY, FEBRUARY 18, 1986

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

The subcommittee met, pursuant to notice, at 2 p.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Pete Perkins, professional staff member and Marty Kress, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. This hearing of the Subcommittee on Science, Technology, and Space will come to order.

We are here, as all of you know, to begin the inquiry of the Congress, and most specifically, of the Senate into the tragic events of January 28, 1986, and to help give us the necessary insight into what actions the Congress should take as a response to that tragedy, and what changes, if any, are necessary in our own space programs in the future.

We are delighted, of course, to begin today with two very distinguished Americans who have accepted the President's challenge to head up the Commission investigating the causes and making recommendations to prevent the recurrence of the January 28 tragedy. They are most welcome here.

It is not the purpose of this subcommittee either to duplicate or to second guess the work of that Commission, but to hope that we can help it in answering questions which are asked by everyone in the United States. NASA has been one of the most successful and one of the favored agencies of the Government of the United States, leading our exploration of space, tangibly illustrating American technological leadership at the cutting edge of knowledge. And just as everyone in the United States has had a warm feeling for NASA, everyone is concerned about any errors or any accidents in which it is involved.

It is my intention as chairman of this subcommittee, and I believe the intention of all of the members of the subcommittee to inquire into four distinct subjects. The first, of course, are the events which led up to the launch and to the tragedy itself. That is, of course, the particular mission of the President's Commission. But as it goes through its work, as it completes its work and makes its findings and recommendations, we wish the fullest possible

knowledge both for the subcommittee and for the people of the United States of the mechanical process, that is, what physically went wrong and lead inevitably to this tragedy, and what defects, if any, there were in the decisionmaking process which led to that launch overlooking those physical problems.

Second, the chairman at least wants more detailed answers than have been provided so far into whether in connection with this mission or any future mission it is possible after launch to separate a shuttle vehicle from solid rocket boosters which are still in operation for any kind of emergency landing or ditching, even at sea. So far we have been given negative answers to that question, but we wish to inquire into them both in connection with this ill-fated mission and any mission in the future.

Third, of course we have a great concern which I know we share with the Commission as to the future of the shuttle program. Now, when will we be satisfied that we have discovered and surmounted the mistakes, technological or otherwise, which led to this tragedy? When, therefore, is it appropriate to restart shuttle missions? Connected with that, of course, is the question of who should fly on those shuttle missions?

Mr. Chairman, I feel strongly that we should require the same degree of safety and assurance of reliability for our professional NASA crews as we should both for civilians who are the employees of various contractors and civilians like Christa McAuliffe, who were going for other or for educational purposes. That is to say, when the shuttle is safe enough for our crews, it should be safe enough for anyone else to ride in it.

And fourth, of course, is the question which is the peculiar province of this subcommittee and its parent committee of the Congress to answer, and that is, "What is the direction of the future of the U.S. Space Program." Should we build a new fourth orbiter? That question has grave implications as to the feasibility of the space station. It has very important implications in the whole direction of our future in space.

Have we been relying too much on manned space vehicles, and have we ignored the possibility or the desirability of having many of these missions conducted in unmanned space vehicles?

The question of a fourth orbiter is one which the subcommittee is probably going to have to answer relatively soon as we look forward to budget decisions which are going to be made in the almost immediate future, and the imminent loss of a reasonable capability to manufacture such a shuttle. That question, of course, is not one which the Commission headed by Secretary Rogers was asked to answer. Their deliberations, of course, are focused on the first of these questions, primarily, but with implications as to all of the rest.

This is an important hearing. The Commission's work is very, very important. We on the subcommittee want to facilitate and to cooperate with it and to learn from it a sufficient amount so that we can intelligently make the decisions about the future of the space program which are our province to make.

Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

First, let me say I very much share your sentiments, and I think the initial statement which you have made here sets forth our task I think clearly and very completely, and it is one that I want to work on with you to see that we meet it and meet it properly. I will not attempt to repeat all the things that you have said, although I would like to add a couple of thoughts of my own.

Certainly this is a very sad inquiry that we begin today. The loss of the shuttle and the astronauts was a tremendous blow to the country. In many ways I think as we have come to know the astronauts themselves even better since the accident in terms of stories that we have read and profiles that have been done, it is as if they are members of each of our respective families. I think Americans across the country feel this way.

So we have a bond to them having been lost in this accident, to know why, what can be done to prevent any accident of this kind from happening in the future, to the extent that we have that capacity, and to see to it that we proceed in a measured way and in a safe way so that future astronauts are accorded every safety measure that we can reasonably provide, both technically, but also with respect to the process by which decisions are made, whether it is launch decisions or sequencing decisions, in terms of how fast we try to move from one step to another.

But I think all of these issues are probably ones now that we have to look at together as a nation and make some decisions about.

Over the years, the men and women of NASA have clearly done an outstanding job of managing America's space effort. Truly incredible goals have been achieved. While it seems like a long time ago now, we carried out successfully six manned missions to the moon. People left our planet and made that journey and landed safely on the moon and carried out the work responsibilities there and came safely back. And of course, all of the previous shuttle missions in the latest chapter of our space program, I think, help underscore what has been an astonishing record of success and safety, with the exception of the previous accident many years ago, the fire on the pad, and of course, the accident that we are here to focus on today.

And so, while as the chairman has said we are going to examine every aspect of how this accident happened and how we deal with it and what the policy decisions are that have to be made for the future, I think that accident has to be weighed against a truly remarkable record of NASA accomplishment that stretches now over nearly three decades.

So clearly we must find the causes of this accident and correct them, and we will. The space program must go forward, and it will. Significant policy adjustments and decisions will have to be made, and working together, we will make them. It is clear to me that our manned exploration of the heavens will continue, and we will do it with measured steps within the bounds of our technology and our available resources.

The available resources part is becoming more and more difficult because of pressures on the deficit and Gramm-Rudman and other things, and we will have to deal with that down the line in due course. I think it is essential that NASA, particularly in light of all the stories that are being written and a lot of the speculation that is loose, I think it is essential that NASA emerge from this inquiry stronger and wiser. That is much easier said than done, but I think that has to be where we end up, however tortured the steps that are required to get there. I think we owe that to the seven astronauts who were lost and to their families, and I think we owe that to the American people. And I think in due course we will meet that responsibility.

Senator GORTON. The distinguished chairman of the full Committee on Commerce, Science, and Transportation.

OPENING STATEMENT BY THE CHAIRMAN

The CHAIRMAN. Mr. Chairman, I think you and Senator Riegle have done an excellent job in setting forth the purpose and the objective of this hearing, and I congratulate you on your statements. I share your views completely.

Obviously this is a most important subject. I think that it is important as we go into it to reiterate just exactly the kind of thing that Senator Riegle just finished saying, that the space program has been one of the prides of this country. It has been an enormously successful program.

The purpose of an analysis of the disaster is to make sure that this kind of accident is not likely to happen again. But I think as we go into it, it is very important to reiterate the strong support that Congress has and that this committee has for NASA and for the space program.

Senator GORTON. Senator Hollings.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Thank you, Mr. Chairman.

At the time of the shuttle tragedy I reacted by saying, well, back 20 years ago we could really know what caused the fire in the capsule at that particular time. We had the evidence with us. Now we will never know really how this thing happened because all was lost. I just did not think with that type explosion any evidence would be left, and now we learn differently. We also learn all about the weather, the O-rings, the tensile strength of the solid rocket booster, the admonition that was going on for the past 3 years by the manufacturer. At this particular juncture the shuttle disaster seems like an avoidable accident rather than an unavoidable one. The only way that we can support the space program, if we are ever going to maintain any credibility and support for it, is to make absolutely sure that no accident like this will ever occur again and that the circumstances that could cause it never again be allowed to develop.

So we will be looking very critically, and I will discuss this with Dr. Graham at the appropriate time. I want to make sure that this committee gets every bit of evidence so that once and for all, when we do hear, as we are going through this task, that we hear it all.

Presidential Commissions—and I have the highest regard for the Attorney General and former Secretary of State, I do not know of any more outstanding American than Secretary Rogers to head it up—but I have served on Presidential Commissions, and it is just impossible to get all of the situation together. I am glad they went down to the site. I hope they will follow through with their own investigations and everything else, because typically what is served up is what the particular agency will bring to you, and sometimes you are not smart enough to ask all the questions, and an adversary type proceeding of investigators is necessary to really get us to a conclusive result.

And that is what I have in mind in this particular investigation, that we not be shielding any information in this committee, because we are the ones who really are supporting the program, and we are the ones who will have to try to reestablish the credibility of it.

Senator GORTON. Senator Trible.

OPENING STATEMENT BY SENATOR TRIBLE

Senator TRIBLE. Chairman, I too am pleased that we will have the opportunity to discuss with the Commission their investigation, and that work is vital to America's space program. While the *Challenger*'s fate reminds us that great achievement is so hard won, we must sustain the effort that will ensure America's preeminence in space. We must continue to unlock the mysteries of the solar system. The space shuttle and the space station are the tools that will provide us with the basic knowledge that we require for our future and will give us a stronger economy, more prosperous future, and a better world.

And so I would hope, Mr. Chairman, that today we could look forward as well as backward as we begin this process.

Senator GORTON. Senator Gore.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you, Mr. Chairman.

The American Space Program is truly a national treasure. The efforts of NASA during the past 25 years have been the cumulation of the best in our national achievement, from the Wright Brothers on down to what, until recently, was a successful Shuttle Program. None of us can forget the first manned space flight by Alan Shepard, the successful orbit made by our colleague John Glenn, and that most stirring moment when Neil Armstrong, who is here today, first stepped on the Moon. The Space Program has been and always will be a source of national pride, inspiration, and progress.

For these reasons, the National Aeronautics and Space Administration has always had the overwhelming support of the Congress. The benefits of the Space Program have been obvious to most of us here, and I can assure you it will always have my support.

But this support cannot be unconditional. As with any other Government agency, the Congress has a constitutional responsiblity to ensure that NASA is fulfilling its potential.

So recent reports suggeting that a certain element of laxity has taken hold at the agency are indeed disturbing. First we heard reports that a gantry arm banged into the external tank a few days before the ill-fated launch. Then on one of the aborted efforts to launch flight 51-L, when it was decided to evacuate the crew, a bolt on the hatch to the orbiter was stripped. When a drill was retrieved to open the hatch, it turns out the battery was dead. Granted, these were minor incidents, but they hardly reflect the first rate operation we have come to expect.

What is clearly not a minor incident is the fact that the temperature of the suspect right hand solid rocket booster was measured at 7-9 degrees, yet apparently the danger sign was ignored. If that in fact turns out to be a major link in the cause of this disaster, I believe that NASA should take another look at its chain of command for shuttle launches. I applaud the Presidential commission's action to remove anyone directly involved in the decision to launch, for an investigation can scarcely be objective if individuals are allowed to pass judgment on their own actions.

I am also concerned Mr. Chairman, that NASA may have ignored some of the risks of space flight, and that the agency may have become prematurely confident about the success of this program. The agency seemed to have deemed the shuttle to be ready to operate like an airline, when in fact it was still very much a research project, however successful. This lead to what now appear to be mistakes, such as allowing non astronauts to fly. I believe the Shuttle Program will continue, but we avoid a tendency to get ahead of ourselves, and what seemed to be proclivity to ignoring risks.

Finally, Mr. Chairman, I would like to ask for a brief moment of silence for the seven brave souls who gave their lives in pursuit of the last frontier.

Senator GORTON. SenatorKassebaum.

Senator KASSEBAUM. I have no statement, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

OPENING STATEMENT BY SENATOR ROCKEFELLER

Senator ROCKEFELLER. Mr. Chairman, I would like to make just one comment.

I do think that we have to find out everything we can about the investigation. I think that the investigation of NASA by the President's Commission will do that in large measure, perhaps entirely. But I think as you indicated, our longer term objective on the subcommittee and full committee needs to be to fully consider the policy implications and the budgetary implications for the space program and its future.

I think it is fair to say that in the aftermath of this tragedy, all of us are fully for the NASA program and its continuing. But we also have to understand that with a number of mishaps and problems and evidences of insufficiencies, we are still dealing with a shuttle program that is in the R&D stage. That has to sink in. We have a responsibility to be supportive, but we also have a responsibility to be responsible. If we are going to go forward with the space program, we have to fund it in a way which will make it safe

for the long term and allow it to do the proper balance of things, not only military and civilian, but also those things which hold promise for the cure of cancer, anemia, diabetes, and other extraordinary things for human welfare which are going on, currently going on in space.

And so the space program should be balanced. We must find out and get to the bottom of what happened. I think the Commission, the President's Commission, will do that. Then I think we, on the committee, have to take the longer term view of our role as an oversight committee and the future of the space program. We are responsible for the future of the NASA program and to restore it to what it has been, and to restore the full confidence of the Nation.

Senator GORTON. Senator Ford.

OPENING STATEMENT BY SENATOR FORD

Senator FORD. Thank you, Mr. Chairman.

As you know, I am not a member of your subcommittee, and I want to thank you for allowing me to sit in with you today.

There is an overriding need in my mind as it relates to what happens from this hearing and from the President's Commission. There was a great deal of excitement and anticipation among the students of this great country because of the teacher being on the shuttle. It almost had become a routine operation; not many people were worried about it, particularly the major networks. Now with all of the students that were watching in anticipation of the classes to be offered, I hope that we can find some answer that will be given to them, that this will not turn them off as it relates to their desire, their hopes, their anticipation of the future.

Mr. Chairman, I think the hearings are in good hands with you and Senator Riegle, and I look forward to participating with you. And thank you again for allowing me to sit in with you.

Senator GORTON. Thank you very much.

We will now be honored to hear from Secretary Rogers and from Mr. Armstrong.

Mr. Secretary, Mr. Armstrong, the subcommittee certainly wishes to welcome you here and to thank each of you individually for your willingness to take on what is a very difficult task and what is in many respects a very unpleasant task but one which is vital for an understanding on the part of the American people as to what happened, and vital to ensuring that out of it we build a stronger and safer space program.

Your roles are very, very important and are to be commended.

Secretary Rogers, you may start.

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

Mr. ROGERS. Thank you, Mr. Chairman, members of the committee. Mr. Armstrong and I appreciate this opportunity to appear before your subcommittee to talk briefly about the work of the Presidential Commission. It was helpful to me to hear your views,

to appreciate the approach that you give to the work of this Commission, and of course, the work of your subcommittee.

The mandate given to the Presidential Commission by President Reagan was to investigate thoroughly and to report fully to the President on the tragic loss of the space shuttle *Challenger* and its crew of seven on January 28, 1986. The President has asked the Commission to take a hard and objective look at the accident, make a calm, deliberate and independent assessment of the facts, find out if possible how this accident happened, the causes—the cause or causes, and to recommend ways to avoid a repetition of this tragedy; and finally, to submit a full report within 120 days of the Commission's formation on February 3.

I know the subcommittee and other Members of Congress will want to review the Commission's report after it is submitted to the President. At this stage I simply want to outline for you some of the principles and objectives that will guide the Commission in its work, which is already well underway.

I might say in response to some of the comments that members of the committee made, I am sure you realize that we have only been in operation for 12 days, so there are a lot of questions that were raised that we are not in a position to answer. I do think, however, that we have gotten off to a good start.

First, I think it was important that we made it clear that our review will be independent. We must and will rely in large measure on data collected by NASA because there is no other reasonable way to obtain it. However, the Commission evaluations, conclusions and recommendations will be its own. The investigation will cover the NASA decisionmaking process. Our intensive review to date has indicated that the decisionmaking process may have been flawed, and I say the process may have been flawed. We have not said the decision was flawed; we said the process may have been flawed, and we base that on testimony we have taken in executive session.

This is not to say—and I want to emphasize—that there is not any question in my mind or the committee's mind about the reliability and trustworthiness of NASA officials. They have given the Commission 100-percent effort and support, and we appreciate it, and of course, they will be available at all times to provide information and help as needed.

Second, Commission members bring to their task an impressive variety of skills and expertise that enable them to ask the right questions and to understand, analyze, and make sound recommendations about the facts.

The Commission acted quickly, I believe, to retain a highly respected and qualified executive director, Dr. Alton G. Keel, Jr., who in turn is rapidly assembling a capable staff to support the Commission in its work. In consequence, that work is well and quickly underway.

I might say that since we were sworn in, we have had two long public sessions. We had four long executive sessions, including a 9-hour session in Cape Kennedy, and another 5-hour session, one on Thursday and one on Friday. We have taken a great deal of testimony. We have done that without a staff so far and without any space yet, but we hope to get space in the next couple of days.

And so we do have, I think, a lot of information. We have not had a chance to assimilate it fully. We have not had the transcripts made of all of the testimony that we have taken, but we plan to do that soon. The Commission members are working, I think, very diligently and are able to work long hours and to be available at any time.

Now, our goal is a thorough and comprehensive review, culminating in a well-documented and researched Commission report that will put all relevant facts on the table. Our review will be as comprehensive in scope as is possible within the time constraints under which we operate. While it would be impossible at this stage to list every avenue of investigation the Commission may determine merits exploration, I can summarize some of the areas we are already examining and intend to review.

To answer the question "what happened?" we are studying all films, photographs, telemetry and other data related to the *Challenger's* launch and flight, the conditions of the launch pad before and after launch. Incidentally, this was the first time that this particular launch pad was used. They had always used launch pad A before. This time they used launch pad B. Whether that has any particular significance or not, we are not sure.

Part of the study, of course, includes a comparison of the data of the sort just described, or similar data from previous shuttle launches, and that is a long, tedious process. NASA officials are now reviewing the movies of this flight and comparing them with the movies of all others, and they are doing the same thing with telemetry, to see if there are any anomalies in this flight compared with previous flights.

They are also looking, as you all know, at the debris from the explosion, and I will say, incidentally, that if they are able to recover the right-hand booster, the chances are we have a much better chance to get a quick solution and answer to some of the questions.

Now, once we have answered the first question, "what happened?"—and fortunately, we have a great deal of information on this, as Senator Hollings pointed out. At the time the explosion occurred, one wondered whether it would ever be possible to really determine what happened, and I think we are going to be able to determine what happened.

The pictures are really quite impressive and tell quite a story. Now, I am sure the committee noticed that NASA, after one of our hearings, released a lot of data about the timing, specific timing of the launch, broken down into small fractions of seconds, and indicated next to that how those were determined, what was happening at that precise time.

Now, specific analysis in great detail is going to be required to determine the significance of each second, and I am talking about fractions of seconds. And that is very complicated work.

Once we solve, if we can, what happened—and I am speaking about the visual results, the results of the telemetry and so forth, and maybe isolate what happened—and as you know, the first focus of attention is on the right booster. Whether that was the cause or effect we are not sure, and we may not be sure for some

time, but the right solid fuel booster rocket appears to be the area where the trouble started.

It was only a few days ago that NASA found out from a study of the photographs that before the first second had elapsed there was a puff of black smoke. You have probably seen this in the paper, a puff of black smoke which appeared before the first second was completed, which was about 25 feet long. And it lasted for 4 or 5 seconds and then disappeared. And then later on—and do not hold me to the time exactly, but later on before the first minute had elapsed, there appeared to be another burst of smoke or something that was visible, and then the plume, and shortly thereafter, the explosion.

And that all appeared particularly in the early part, all appeared on the right booster. And a good deal of speculation has occurred that that resulted from the O-rings and the seams where the segments are put together.

On the other hand, it would be a mistake to focus all of our attention on that because it is possible the external tank was involved. We know that the strut that connects the booster with the external tank was broken. Whether that was broken at that time or later on has not been determined yet, but we expect that we may be able to determine that, and NASA is working very carefully on that.

Well, "what happened?" is but the first question. The second, and equally important question is why? The areas and issues the Commission will explore in trying to find out why include the following: what were the testing and certification procedures for the shuttle, the rocket boosters and other components; what were the problems in the past and how were they analyzed; what concerns had been expressed in the past, and how were they handled; were waivers granted dealing with safety; were there waivers, and if so, why were they granted?

Second, what are the NASA and contractor quality control standards and procedures for the manufacture, handling and assembly of key components? Was there laxity or negligence on the part of the contractors in the performance or maintenance of support duties? What were the effects of weather and other environmental factors, the temperature, the wind and the humidity? And of course, it is important in this case to consider very carefully those factors because it was a low temperature. There was a considerable amount of wind, and all of those things now have to be reviewed, weighed and reviewed in hindsight in light of what happened.

What are the launch commit criteria, and how were they analyzed before the decision to launch was made? How did NASA's schedule and the desire to meet it affect the launch decision? More generally, who were the people and what were the factors involved and the procedures followed to make certain that all factors were carefully and promptly considered before the decision to launch was made? These are among the areas we intend to explore, and as you can see, that is a big job.

The answers to "what happened" and "why" we hope may provide the keys to the final question, "what should we do to minimize the chances of any recurrence of such a tragedy?" No conclusions have been reached as yet, of course. If the right booster rocket is

recovered, it may help to speed up our ability to reach some conclusion. Nothing has been exonerated up to this point. Every aspect of the program and the shuttle itself is being considered. The one aspect that is most likely to be exonerated and probably will be exonerated first, but that decision has not been made, is the shuttle, the orbiter itself.

As far as the evidence that we now have is concerned, it appears that the orbiter performed properly.

When the Commission reaches conclusions whether or not final—and we do not have to wait until the final conclusion—we can make preliminary conclusions to the President as we go along—whatever they are, the temporary conclusions or final conclusions, we will report to the President, as our mandate requires, and we are very mindful of the importance of the undertaking and the interests that this subcommittee and all of our citizens have that the work be done carefully, thoroughly and well.

I appreciate very much your strong support, and I appreciate this opportunity to be here, and I particularly appreciate the fact that the vice chairman of the Commission is Mr. Neil Armstrong.

Senator GORTON. Mr. Armstrong, do you have a statement?

Mr. ARMSTRONG. I have no opening statement.

Senator GORTON. Secretary Rogers, are you convinced that you can complete your assigned tasks in the 120 days which the President has set out as the term of the Commission?

Mr. ROGERS. Mr. Chairman, we certainly hope so. I think it is possible we can. As I say, if we determine the cause or causes quickly—maybe a better way to put it, if we determine what happened quickly, and we are speaking about visually, we can isolate it to an area and be sure that is the case, then I think we can. Certainly I hope we can. That is what we are going to try to do.

Senator GORTON. Are you convinced that you can develop all of the facts which are necessary to make your findings of fact and your conclusions, and can the Commission come up with recommendations with either a small or no staff through its own efforts and through the factual material that you can get from NASA itself?

Mr. ROGERS. Well, we intend, Mr. Chairman, to have a good sized staff. I have not decided yet exactly what it will be, but we have available to us any kind of assistance we need from particularly within the Government. The President has indicated that he wants to be sure that we do a thorough job and that we have adequate personnel to staff it, and that we have a full disclosure of all the facts. So we certainly are going to try to do that. It is going to be tough, but I think we can.

Senator GORTON. Now, am I correct in hearing your statement as indicating that you will come up with a series of findings of fact of what in fact took place physically, and what kind of decisionmaking process was involved, that you will have findings, and that you will attempt to come to conclusions as to the cause of this accident, and on the basis of those findings and conclusions, recommendations as to the future of the shuttle program?

Mr. ROGERS. Well, let me be precise. We certainly will try to do that. The first part of your question, the answer is yes, we are going to try to do that. Now, we never can promise with certainty

that we are going to be sure that we know the cause or causes, but that is certainly what we are going to try to do.

Second, we are going to try to make recommendations to prevent a recurrence of an accident like this or anything in that area. So we will try to make recommendations in the whole field of safety. We will not be required, nor should we make recommendations about the whole future of the space program. That is really a matter for Congress and the President, and not for this Commission.

Senator GORTON. You have quite carefully separated two elements of your inquiry, Secretary Rogers; emphasizing one, the findings about what physically happened, looking at the pictures, reading the telemetry, everything physically which took place, both beginning with the launch and whatever physical findings you can find prelaunch, and you separated that in your own statement from findings as to the decisionmaking process which led up to the decision to launch.

I want to concentrate for a moment on the first of those, on physically what took place.

Can you tell me at this obviously preliminary stage, and can Mr. Armstrong comment on how close you feel you are, how narrowly you have now focused on what the actual physical anomalies were from launch until the explosion?

Mr. ROGERS. I think that is an appropriate question for Mr. Armstrong.

Mr. ARMSTRONG. Mr. Chairman, as was pointed out in Secretary Rogers' testimony, we have not eliminated any possibilities, although, as he said, the orbiter at this point looks clean; the cargo, the TDRS, and the inertial upper stage appear to have been no factor. I suspect that as we build more and more evidence, we will be able to eliminate more and more of the hypotheses, and I would certainly hope that within a reasonably short period of time we will be able to converge to a point where there are only a few serious contenders.

Senator GORTON. Have you concluded as yet that there was a failure or failures in a seal or seals in the right solid rocket booster?

Mr. ARMSTRONG. No, sir. We have not concluded that a specific failure was the cause. It is clear to all of us that certainly failures occurred, but as to the progression of events, we have not yet determined.

Senator GORTON. I think you sort of anticipated my next question.

I take it you have concluded that there was a failure at some point or another in one of those seals but not whether that was the first failure or the cause of, the proximate cause of the explosion?

Mr. ARMSTRONG. We have not concluded there was a failure in the seals.

Mr. ROGERS. Mr. Chairman, you cannot conclude. We see evidence in the area of the seal, in that general area, but as Mr. Armstrong says, you cannot really conclude for sure anything about that except the area where it occurred.

Senator GORTON. And I gather that you are seriously investigating the impact, the effect of the extremely cold temperatures in the

hours immediately preceding the launch, and that it is at least a suspect in having played a major role in the disaster?

Mr. ROGERS. Yes, Senator. Mr. Chairman, I do not know whether you followed our public hearings or not, but we had a good deal of testimony at that time about the weather. We have had a great deal more testimony since that time in executive session, and we have one of our Commission members who was in Cape Kennedy yesterday and today, I believe, trying to get precise details about the weather, to be sure exactly what happened. You would expect that it would be easy to find out what the weather conditions are or were, but it is not as easy as you think.

A word like "ambient temperature" means a lot of different things. I just thought it was what you looked at when you had a thermometer, but it can be—is it in the shade or in the Sun? Is it near a building, and all of these other things. And then there is, of course, the temperature of the booster, the outside, the inside temperature, how do you determine those things?

So we are giving a lot of weight and a lot of consideration to weather factors and related factors.

Senator GORTON. And I take it in connection with the decisionmaking process itself, you are examining in as much detail as you possibly can whether or not there was concern expressed either by NASA personnel themselves, by contractors, or by the manufacturers of the solid rocket booster, and for that matter, by manufacturers of other components, as to the impact of that cold weather?

Mr. ROGERS. Absolutely. We have taken a lot of testimony on that, on the decisionmaking process, and it is our present intention, although no final decision has been made, that we will have public sessions dealing with that whole subject matter in the near future.

One of the difficulties we have is, of course, the subject is so complex and because there are so many factors involved, and because harm could occur if we do not present it thoroughly and in proper order, that we want to be sure that we are prepared for public sessions so that we will have precisely the correct information and that we will be able to present it in a way that is understandable and that those people affected, some of whom may be adversely affected, are treated fairly.

Senator GORTON. That leads me to another question.

Obviously you are going to come up with a set of findings, and I suspect that those findings are going to be detailed.

Do you intend to make fully public all of the information which has led to those findings and not just the information which has come out during the course of the public hearings? Is this committee and the general public going to have access to all of the evidence upon which the findings are based?

Mr. ROGERS. Mr. Chairman, all of the facts will be fully made public. We will make them public as we go along to the extent that we think it would not be harmful to the investigation, and in the final analysis, we will make everything public.

Senator GORTON. Are you going to be utilizing what NASA apparently calls a devil's advocate team to test your premises and your findings against?

Mr. ROGERS. We have 13.

Senator GORTON. That leads incidentally to another question. The Executive order under which your Commission was formed allows up to 20 members.

Do you have any insight into whether or not there will be any additional members appointed to the Commission?

Mr. ROGERS. Not really, except that I think if I am asked, and I may be asked, that the present size of the Commission is just about right. We have been able to move quickly. We are homogeneous and cohesive so far, and I hope that we will continue that way, and everybody has participated to the full extent. And I think if the Commission was much larger, it would not work as effectively.

So my own impression is that probably we will stay the present size.

Senator GORTON. Does that mean that you are operating as a committee of the whole and you have not delegated specific tasks to specific members?

Mr. ROGERS. Up to this point, that is true, Mr. Chairman, but that is going to change. In fact, one of the things we are going to do tomorrow—and we have some of the Commission members working on it now—is to figure out how we could break down into working groups or subcommittees, or however you want to call it, so that we can do a variety of things at the same time. And those subcommittees or working groups will report back to the committee of the whole later on. It will expedite the work. We do not need everybody listening to everything all the time.

Senator GORTON. One last question before my time is up, Mr. Secretary, and that is your assurance that you are going to follow through on the human as well as the mechanical antecedents to this decision and to this disaster, and that subject to fairness to given individuals, you will follow that inquiry wherever it goes, and whoever may or may not be embarrassed in connection with that.

Mr. ROGERS. There is no question about that.

I was interested in Senator Hollings' comments, and I can assure him that we were going to do that.

Senator GORTON. Senator Riegle.

And incidentally, for members of the committee, in order that everyone may ask questions, we will limit them to 10 minutes each and then have a second round if anyone wishes.

Senator RIEGLE. Thank you.

Secretary Rogers, I take it that you were involved in whatever other professional duties you had at the time you got the phone call to serve in this capacity, and I take it that you in a sense stepped away from whatever it was that was occupying your time professionally, and you are now devoting full time to this, I take it?

Mr. ROGERS. I am so far. I do not know whether I will be able to do anything else or not, but so far I have devoted full time to it.

Senator RIEGLE. And I take it that you are available to continue to do that for the foreseeable future?

Mr. ROGERS. The foreseeable 120-day future.

Senator RIEGLE. So if it were to run longer than that——

Mr. ROGERS. I would like to end it at 120 days.

Senator RIEGLE. Mr. Armstrong, is that true for you as well? Are you able at the present time to devote, in effect, full time to help-

ing to lead the inquiry, and if so, will that continue to be true for the number of months into the future?

Mr. ARMSTRONG. So far I have spent full time, Senator, on the Commission, and I expect that I will be spending substantially full time through the remainder of the 120-day tenure.

Senator RIEGLE. Well, I appreciate that because I have been very impressed with the quickness and the seriousness of the work of the Commission, and I appreciate, Secretary Rogers, your stressing at the outset in your statement the independence and how keenly you feel about that. Knowing you as many of us do from over the years, we know that when you say that, that is exactly what you mean. I think it is essential that that be clearly understood and there be no doubt about it, and the public have every confidence that the investigative work that is done asks all of the hard questions, uncovers everything that needs to be found, lays it all out, and that we do not miss a thing.

And I take it that that is the purpose, as you two see it, and you are determined to do that.

Mr. ROGERS. Yes; that is right, Senator.

Senator RIEGLE. We have to begin to make some decisions ourselves here with our colleagues about budgeting decisions and other kinds of long leadtime decisions that may or may not fit in nicely with the continuing investigative work of the Commission and NASA's other investigative efforts and so forth. It would be very helpful to us to be able to stay abreast of what you are learning and finding so that we do not have to plow all of the same ground ourselves, to try to have a sound basis for the judgments that we are going to be called upon to make. And we have asked to have the opportunity to have access to the transcripts as you develop them so that what information is being collected we have the chance to assimilate and learn from as well.

And thus far, the response that we have gotten from the Commission staff level has been that that is not possible, and that those transcripts are not available to us.

I would like to ask you to comment on that, and I would hope that we would not get stuck on that point, if that is a point of difficulty. I would like to suggest that possibly the senior staff members of this subcommittee and committee who have top security clearances have an opportunity to sit in on some of these sessions, not as participants but as listeners, so that we do not end up losing a lot of time and ability or to have a duplicative effort that otherwise would not have to be the case.

Can you be helpful to us in that respect?

Mr. ROGERS. Well, Senator, it is a difficult question. As you know, I would like to cooperate as fully as I can. I do not think we can do that because we have had so many requests from people to sit in on our Commission work, and after all, it is a Presidential Commission, and because of the separation of powers, I think we should continue to have the option of proceeding in executive session when we think it is appropriate.

I would be glad—and, of course, we will make all of the other transcripts and other evidence available to you as soon as it is made public, and we will try to give it to you in a way that is easy for you to digest. And I do not believe that the work that you are

speaking about will be or would be of any particular help to you because we do not intend to have long executive sessions where we develop information that is not fairly soon made public. We will try to make it public as we go along because I think it is too important for the Nation to feel that we are developing information—sort of confidential information—that nobody can have access to.

I would like to think about that and maybe work with the chairman. Certainly I would have no problem with briefing the chairman about our work, and if there was something that he felt was really vital to the work of the committee, I would like to think about that.

Senator RIEGLE. I want to pursue this just a little bit further because there are a number of very complicated decisions that are going to begin to jam up against one another. We are running behind on our launch schedule because of different delays that we had experienced along the line, and in NASA now. One of the vehicles is, of course, gone, and so we have had a 25-percent reduction in the capability to take these flights. There will be some delay here now, an unknown length, until we get these answers and make corrective steps.

But we are going to have to begin to make some decisions about how aggressively we can pursue the commercialization aspect, which has been something that has been important. We have got star wars considerations that bear on this. And so it is not just this committee but other related matters to this.

And what I would hope is that—it seems to me that we have parallel responsibilities here. I am sure you must have some reason to need to go into executive session, but I do not quite understand why whatever you are learning is not, ought not to be available to the rest of us who have work duties that are parallel in nature that require us to understand the same things. In other words, I do not know that we would want to rely just in the end on a digest of opinion, and probably we would end up finding that we would have to sort of go over the same roads.

It seems to me we ought to be able to go down the same road together more or less at the same time. And so I guess I am somewhat at a loss to know why there is any reluctance there.

Mr. ROGERS. Well, I think you know, Senator. I do not think it is hard to figure out because of the separation of powers, just as the executive branch does not normally sit in Senate hearings, private sessions, and would not want to and would not ask to.

This is a Presidential Advisory Commission, and we have—we think we have the right and continue to have the right to hold executive sessions as we see fit.

Now, as I have said, if at any time there is something specific that you or the chairman or any member of the committee thinks that would be vital to you in the assessment of your responsibilities, we would want to consider that. I do not think that is going to happen in real life. I think that the things that we are going to develop in executive session are going to be very soon developed in public session, but I think we have to maintain the separation of powers, and I think we have to work as a Commission, and otherwise I have had a lot of requests from Members of the House who want to sit in. There are a lot of people that have a very vital in-

terest, and if we start having that, we will just have a joint Commission with Members of the Senate and the House, and I do not think that is desirable.

But I will try to work with you. If you really have something in mind that you want to know that we are in a position to tell you, we will try to tell you.

Senator RIEGLE. Well, I appreciate that. The problem is that I am not sure from the vantage point that the Commission is sitting at the moment that the incredible timing and budget pressures that are upon us here at the present time——

Mr. ROGERS. Could you illustrate what you mean, Senator?

Senator RIEGLE. Well, yes. There is a very serious question as to whether or not we are going to need to build another shuttle. This is a long lead time and it is very expensive. It is estimated it would cost us $2.2 billion. Some people now say we should have built five in the beginning. We built four. Now we have lost one, so we have three. And so if we are going to have to build another one, maybe we should build two.

There is the question of how long we want to try to use the shuttle technology to carry out our space program does it go beyond the years 2000 to 2005? We are now at a point where we have got to make some very major budget decisions.

Mr. ROGERS. Could I say on that, though, if we get to that point where we reach a conclusion, we would make that available to you.

Senator RIEGLE. Well, but——

Mr. ROGERS. You do not want to be involved in the whole process of reaching the conclusion, do you?

Senator RIEGLE. I think the question of how quickly we might be able to start flying again and under what circumstances, and how we are going to juggle the competing payload requirements because we are not going to be able to handle everything that we had planned to handle, we are just not going to be able to do it, and so time is important here.

I guess the thing I am having a little bit of difficulty with is that when you develop a transcript, you are asking questions and you are getting information. I guess I am somewhat at a loss as to why that information you would have any reluctance in sharing that base of information with the committees of jurisdiction.

Mr. ROGERS. I really do not know that this deserves a lot of attention. Let me say that we are not in a position to make that available at the time we take it because we think that it is very important that this evidence be presented in an orderly fashion and in a way that will not be harmful to individuals, and we are going to try to do it that way. We are not going to withhold much information very long.

Now, I cannot believe that is going to make all that difference to you, whether you know it on Tuesday or next Thursday, and we are going to try to do it quickly. And if you find that you think we have some information that would be helpful to you, please tell me what it is and I will try to get it to you. I will try to deliver it myself.

Senator RIEGLE. In that vein, let me mention one specific, and that is, we have had a lot of information develop now. You have mentioned some today with respect to the questions about the O-

rings, and there are difficulties in that particular area, and information has come out that suggests that this problem was known about as a problem for a long period of time. For whatever the reasons, certain steps were taken and maybe others were not, and we will get to the bottom of that.

If there are other problems other safety issues and questions that have been around for a period of time that either have not been correct or have been downgraded in importance or put in a line to be fixed after something else is fixed, or perhaps has not been moved on aggressively because we have been short of money or short of staff or short of this or short of that, I think it is important that anything that comes close to being in that category be identified and red-flagged immediately so that we know about it and we do not find out about it later on down the line because we have got classified transcripts here.

Mr. ROGERS. I think that is correct.

Senator GORTON. Senator Danforth.

The CHAIRMAN. Mr. Secretary, let me express my thanks to you and to the other members of your Commission, Mr. Armstrong and others, for the considerable sacrifice of your time and your talents that you are putting in to render a very important national service.

You have now been at this, I think, you said 12 days.

Mr. ROGERS. It seems longer.

The CHAIRMAN. How are things going at NASA? I would imagine that that has been very traumatic for the organization.

Are people down in the dumps, or is there a sense of optimism for the future?

Mr. ROGERS. Well, it is a combination. I think you have put your finger on both things. First, the event was overwhelming, and there was obviously a lot of time spent on just getting their thoughts collected, and of course, there is a lot of public attention focused on NASA and a lot of stories to the effect that their morale has deteriorated and so forth. And I am sure that there is some of that.

As far as the Commission is concerned, as I said in my statement, we have been very impressed with the way they responded in great detail for this information. They have provided witnesses, information. They have released a lot of information at our suggestion. They have prepared witnesses and gotten information on a 10-hour notice and so on and so forth. So I detect still a great esprit de corps there, and I think it will continue. But it is going to be a tough period for them.

I mean, there is no way around it, it is going to be difficult, because when you lay out all the facts and you hear all the rumors and all the speculation, you know they are going to be under the gun, and they are going to feel bad about it, and I do not know any other way to do it. I think if all the facts are laid out and the investigation is completed, however unpleasant it may be, and then we get back to square one, and people start working, and the space program continues, and certainly all of us on the Commission I think are enthusiastically for the space program, as such, we think it is very important and in the national interest. But in the process, it is going to be difficult for them.

I am impressed with the key people who seem to have their chins up at the moment.

The CHAIRMAN. Well, your role and our role is very sensitive in this regard because it certainly was a very, very traumatic event for everybody at NASA, and we want to find out what happened and make sure that it does not happen again, and yet indicate our encouragement and support.

Your statement includes a statement which says our intensive review to date has indicated that the decisionmaking process may have been flawed.

Could you elaborate on that sentence and tell us what the meaning is and whether this is some sort of preliminary finding, or is it just a matter——

Mr. ROGERS. I had better wait to say it is. We drafted it carefully to try to say exactly what we meant. We said it because we wanted to be sure that no person who is involved in the NASA investigations be placed in a position of investigations himself. Also we did not want to single out anybody at this early stage, because we do not have any conclusions about anybody. But we think the process itself may have been flawed, and I couched as it "may have been flawed."

I think that as we go along and in talking about executive session vis-a-vis public session, as we go along, I think the public sessions will disclose how we think the process may have been flawed. That presentation we want to make very carefully to be sure that all the facts are accurate and all the people who might adversely be affected are given fair opportunity to be heard so that there is no misjudgment or misinformation, or that anybody could say that they were treated unfairly. There certainly is not—there is nothing in the picture which refers to the trustworthiness or the integrity of the people involved.

The CHAIRMAN. And certainly no hint, even by the sentence in your statement, that there has been sort of a slipshod or cavalier approach to the operations at NASA.

Mr. ROGERS. Did I say that?

The CHAIRMAN. No. I am saying that that certainly should not be read into your statement.

Mr. ROGERS. No.

The CHAIRMAN. Some of the stories in the press have expressed concern on how something like this could happen and there has been some speculation that NASA's shuttle operations have been sort of a rush-rush operation. I have to say that as a lay person looking at NASA, NASA seems to be very cautious.

I mean, a couple of days before this particular launching they delayed the launch because of perceived bad weather, and it did not turn out to be bad weather.

In other words, any speculation that they were somehow under the gun or rushing to get the flight off is not something that you have indicated by this particular statement?

Mr. ROGERS. The only conclusion that we have reached is the one that you read, and I really do not want to go beyond that at the moment. We just have not reached any other conclusion.

The CHAIRMAN. I understand. Just to explain a term, when you say in your statement "were waivers granted and why," what does that mean?

Mr. ROGERS. Well, Mr. Armstrong can explain that better than I.

Mr. ARMSTRONG. Every step in the NASA process is documented at various levels of approval, and the requirements and the meeting of requirements is documented. When a particular item or component or procedure or process does not precisely meet its specifications, that is reviewed to see whether it is still adequate, even though it does not meet the specifications. And if it is deemed to be adequate, a waiver is granted that that specification be overruled.

And that has happened in a variety of circumstances over the years, but we in the Commission feel it is very important that we review all of these waivers, particularly on things that are of a critical nature, and see if the process whereby those waivers were granted was complete and adequate.

The CHAIRMAN. Thank you, Mr. Chairman.

Senator GORTON. Senator Hollings.

Senator HOLLINGS. Mr. Armstrong, knowing what you know now, as an experienced astronaut would you think it would be safe to get in that shuttle under the same circumstances and conditions?

Mr. ARMSTRONG. Well, I am reminded, Senator Hollings, of a meeting with John Young, a former colleague and current astronaut, immediately after the accident. And he said: We are with you on this; none of us want to go again until we really understand what happened and get it fixed. And that is the same way I would feel at this point.

Senator HOLLINGS. In other words, it could have been avoided perhaps?

Mr. ARMSTRONG. I am not in a position to judge that yet, sir.

Senator HOLLINGS. Secretary Rogers, with respect to the staff, I am anxious that you have an adequate staff. And with respect not just to the people correlating all of the statements and findings, but rather investigators on the ground. How many investigators does the Commission have?

Mr. ROGERS. Well, depending upon what you call them. We have got a couple of lawyers. I am not sure you would call them investigators.

But we will get, as I say, it is 10 or 12 or 14, something like that altogether. A lot of this is going to require a great deal of reading. It is not investigators in the police sense. It is reading documents and understanding what they mean, organizing hearings, talking to witnesses, and that sort of thing.

And so we may have a staff of 15, but we will have an adequate staff, I assure you. And we are going to have good people. We have our choice of the very best people available.

Senator HOLLINGS. Well, that is the point. In my experience in investigating cases, I would want 15 to 16. I would want four steeped in the science and space technology, four or five down there going around at Canaveral talking to everybody, eating lunch with them. You would be amazed what you will find out.

Similarly at Huntsville and similarly at the Thiokol plant in Utah, and similarly at NASA headquarters. So if you wait to just read what is given you, I have found out in these kind of actions

and cases that if you really just hang around you will find out more that what you ever knew.

Mr. ROGERS. I have been involved in a lot of investigations in my lifetime, and I am not going to hang around and we are not going to just sit and read. In fact, I got my start as a Senate chief counsel for a Senate investigating committee, the old Warren investigating committee.

And I know how to handle a staff. We are not going to sit around. What we have done lately is we have gotten a lot of people in the room and asked them all at the same time, rather than having a gumshoe walking around asking some person one at a time.

At our meeting at Cape Kennedy, we had probably 40 people in the room from Thiokol and NASA, and we got a lot of information.

Senator HOLLINGS. I understand. And yet, I began to get concerned about your product, in that you need some gumshoes around. That is the whole thing, the trouble with presidential commissions.

I have been on them. I have investigated intelligence activities in this government under the Hoover Commission, and it is based on what you are fed by the FBI and the CIA and the security agencies and otherwise. So if you can get some investigators—and I do not mean running around like in a criminal case, a gumshoe—but if you get some experts down on the ground and they talk to the people that did the launching and talk to them about last month and December when they had trouble and the crane hit the external tank and talk to some other of the crews and everything else.

They will not gather around in a room. Those fellows just do not want to get involved in Presidential commissions. They have got their jobs and will not do much talking. But you would be amazed if you eat in a restaurant around there for two or three weeks in Canaveral what you will find out.

Mr. ROGERS. Well, I appreciate your comment, Senator. Let me say first, I think we will do a good job. I hope we will.

And I do not want to promise that you will be satisfied with everything, but I think you will be satisfied. Let me say this. We have—one of our Commission members is down there today. He is a Nobel laureate and he is investigating the way you would like him to investigate, and we have other Commission members who are going to do that, too.

And they are better positioned to find out and analyze some of these things than the average detective would be. I do not think we are going to need so many so-called detectives. We are going to need people who will do a lot of work.

And as I say, we have got some very capable people on the Commission. We have an Air Force general who has been through one of these investigations just recently, involving a space launch out in California. He has gone through it all and made the whole report and knows exactly how it was done, and it was done well.

And so he is going to be able to give us a lot of help, and we will have him supervise one aspect of it. And he will have people working for him.

And so I think you will find—at least, do not hold me to giving you all of the answers for the first 12 days.

Senator HOLLINGS. I do not expect that, and that is what I am not trying to get at. I am trying to get to a really conclusive answer, so that it will be conclusive. You know, we are still investigating the Warren Commission report around this place.

Mr. ROGERS. I know, I am familiar with that.

Senator HOLLINGS. That is what I am talking about, because they did not use the CIA. The CIA furnished it to them and they never went in behind it, and then you had to get investigative reporters and people writing books and everything else.

And so I am not questioning the competence of the Nobel laureate. I have been reading with great interest what he has said, and there is no question about the competence of the Commission itself.

But investigating cases you need some investigators around. And you have been in 10 days or so and you do not have any right yet. You all have been working hard and you really have brought already to the public attention a lot of very interesting facts. I think you all have not been negligent in any fashion.

But to really get a thorough investigation—and if I served on that Commission, I would say, Secretary or Mr. Chairman, I want to get me about 15, 16 investigators, and send them out ahead of me and just put them over there in Huntsville, Thiokol, and everything around, and just listen and talk to all the people involved. And then they might want to be taking some statements and everything else like that, because there is a lot of valuable information out there.

And that is the way you make a thorough investigation, not just that you have got 40 people in a room or a Nobel prize winner asking the questions.

Mr. ROGERS. Well, Senator, I respect your views and I would be happy to talk to you about it.

Senator HOLLINGS. Well, we might have to do it at this committee level, then, if it is not done at the Commission level. That is the trouble. That is what we are trying to do.

Mr. ROGERS. Well, I am not quite sure why we are having any difficulty. I will be glad to see that we have that type of person available to do work, and I realize that there are occasions when that is important. I was a DA for a long time and I know how to conduct criminal investigations, I think.

And I know that the Warren Commission's responsibilities were different from this. I mean, we are not going to have—I mean, there they had a lot of problems with ordinary detective work, how do you find who shot the gun and all those other horrible things. We are not going to have things like that to investigate.

If we do, I certainly will get detectives. And as we go along, if you think we do not have enough, please talk to me about it. I understand your point of view.

Senator HOLLINGS. Very good.

Thank you, Mr. Chairman.

Senator GORTON. Senator Kassebaum.

Senator KASSEBAUM. Thank you, Mr. Chairman.

I am really here just to learn. I would like to add my congratulations to you for the time and effort that you are giving and the thoughtfulness and the thoroughness with which I think the Commission is setting out on this task.

I would like to follow through with a question that Senator Danforth touched on a moment, and that is—and it is one that requires some sensitivity in handling it, and that is the morale at NASA and the impact of this accident, and the concern that we may be seeing some real veterans at NASA wondering if it is time to move on.

Exactly would you describe at this point—and it has been a very brief time—NASA's role in the investigation and your relationship to it, to NASA?

Mr. ROGERS. Well, may I address the first part of your question first. Of course, the morale of the people in NASA is vitally important. The morale of the astronauts is vitally important.

We are very fortunate to have Dr. Sally Ride on the Commission, and she is in close communication with the people at NASA and particularly with the astronauts. And they are worried. Obviously, they are worried about the safety aspects of this.

But they are—the ones I have talked to, and I have talked to a couple, they are also very enthusiastic about the program. So like all of us here, they want to get to the bottom of it and try to figure out what caused it and see if we can correct it.

But they are not discouraged in terms of the program, I do not think. That gives emphasis to the point that I was making earlier, and that is how important it is to get to the root of this and all aspects made public, so that when we are finished that everybody will have confidence that what we do from now on is going to be safe.

And I think that that is possible. I have to caution the committee, though, that in the process of full disclosure it is very likely that there will be further demoralization. You cannot do both. You cannot have full disclosure, which may disclose embarrassing aspects, without embarrassing the people who are involved.

Senator KASSEBAUM. That is why I was a bit surprised to hear you say that you were going to be making public your observations each step of the way. Do you think there is any problem with this as far as being able to keep it in the full context of the total picture if you are going to make these observations as it goes along?

Mr. ROGERS. Well, I did not mean—if I said that, I did not mean it the way you interpreted it. I said that we are not going to draw any conclusions until—unless we, for example—if it was clear what exactly caused it to happen. If that did occur, we might report that fact to the President earlier on.

I doubt that that will happen. I think the chances are we will take the full 120 days and make a report. That is what I meant.

Now, as to the other—and maybe where I threw you off the track was I said that from time to time, in order to make full disclosure, not wait until the end of everything, we will have a public hearing. In order to have the public hearing, we want to have it well prepared, so that it is orderly, so that the facts are presented in an orderly fashion to the public and to everyone else.

In that process, you can cause people to feel sort of down in the dumps, because it may adversely affect the process or individuals, for that matter. Now, we hope it does not, but there is no way—if the facts themselves should turn out to be embarrassing and you

say, we are going to present all the facts to the public, then QED you have got an embarrassing situation.

Sometimes you embarrass people a little bit. I do not know how we can avoid it. That is the dilemma we have. I mean, the natural tendency would be to say do not disclose the facts, let us keep them quiet, let us not tell the public because that might demoralize NASA.

I do not think even NASA wants that. The NASA people have said to us they want everything disclosed, pleasant and unpleasant.

Mr. ARMSTRONG. I would like to add a footnote, Senator. I have talked to quite a few NASA people in the last couple of weeks, and it seems like Americans are at their best when they are under pressure. That is the situation I see, and I do not get this down in the dumps reaction.

In general, I get a challenged reaction, where most everybody that I talk to asks: How could I help; what can I do; I am available and ready and able and willing.

Mr. ROGERS. Without exception.

Senator KASSEBAUM. Well, it would seem to me, with that kind of atmosphere, you really can overcome any demoralization, so to speak, because I think everyone would respect an objective and thoroughly competent investigation.

And I would assume that because you have adopted that procedure you will get the fullest cooperation from NASA, and it would seem to me keeping it on that level, where it remains impersonal and objective, you can only get as a matter of fact full support.

Thank you very much.

Senator GORTON. Senator Gore.

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

Mr. Secretary and Mr. Armstrong, is the Commission now looking at the possibility that a flow of super-cold gas from the main tank may have participated in the lowering of temperatures of the O-rings?

Mr. ROGERS. Well, we are looking at all aspects of that.

Senator GORE. Are you looking at that scenario specifically?

Mr. ROGERS. Well, as I say, I do not want to single out any one aspect, because that gives it undue importance. We are considering all aspects of the weather and how weather might have affected the launch.

Senator GORE. Is a possible leak in the main tank one of the scenarios that you are looking at?

Mr. ARMSTRONG. That is, Senator, one of a number of scenarios that is being investigated still actively as possible.

Senator GORE. Let me ask a question which begins, is it more likely, which is a difficult question to ask. But in trying to understand this quickly—you know, we have our budget hearing next week and, as several members of the subcommittee have indicated, we have got some difficult choices to make in a very short period of time.

We are confronted with evidence that—of temperature readings of 7 and 8 degrees Fahrenheit on the right solid rocket booster. In your opinion—and maybe the question is unfair, but I will ask it anyway. In your opinion, is it more likely that this was caused by

the weather conditions or an anomalous instrument reading or a small leak of supercooled gas from the main tank?

Mr. ROGERS. I agreed that Neil would answer all of these questions

Mr. ARMSTRONG. That particular measurement came from infrared scanning, and the calibration of such instruments is difficult and suspect. And these particular readings that came out do not completely add up, and so that is one of the reasons Dr. Feynman is at the Cape now looking at the calibrations and the assumptions that were made in determining those temperatures, to find out whether that is real evidence or whether that is erroneous evidence.

Senator GORE. A statistical artifact of some kind?

Mr. ARMSTRONG. Yes.

Senator GORE. But if I am not mistaken, the range of error in calibration is probably less than what would account for a 7 to 8 degree reading. And just as a layman, that is something that I have been led to believe.

Mr. ARMSTRONG. I am not a specialist on infrared either, but it is my understanding that your assumption or your reasoning is correct, given the proper assumptions in the first place. And that is the thing Dr. Feynman is looking at.

Senator GORE. So that is one of the things Dr. Feynman is down at the Cape looking at now?

Mr. ARMSTRONG. One of the several things he is looking at.

Senator GORE. Do you agree, Mr. Armstrong, that a reading of 7 to 8 degrees Fahrenheit on the solid rocket booster on the right side prior to launch should have been the kind of finding reported up the chain of command as a factor to be taken into account when the launch decision was made?

Mr. ARMSTRONG. I am sorry, Senator, I cannot answer that question, because I do not have enough background to say.

Senator GORE. Secretary Rogers, do you want to try that one?

Mr. ROGERS. No; I do not want to pick out any factor like that. I think all factors should have been considered, and I hope that they were. And when the record is complete, I hope we will know.

Senator GORE. Well, but you have said publicly that the process by which the launch decision was made may have been flawed. Is this one of the factors you had in mind when you made that public statement?

Mr. ROGERS. No.

Senator GORE. It is not?

Mr. ROGERS. No.

Senator GORE. What did you have in mind?

Mr. ROGERS. Well, as I have said to the chairman, I am not going to get into that today. I am not going behind what I said, and I have said very carefully what I think should be said. And at the right time we will say more.

Senator GORE. Who had final responsibility for the launch decision?

Mr. ROGERS. Well, that is another matter we want to develop, and we will develop that in a public session before too long.

Senator GORE. Did Mr. Beggs participate in the launch decision?

Mr. ROGERS. I do not know.

Senator GORE. Do you know, Mr. Armstrong?

Mr. ARMSTRONG. I do not know. I would not normally expect so, but I do not know. It has not come up in our testimony.

Senator GORE. I would not normally expect him to be.

Mr. ARMSTRONG. It normally would not—the Administrator of NASA normally would not be in the chain, I do not think, sir.

Senator GORE. All right.

Now, in the moments prior to the catastrophe—and again, this is one of those questions which I will certainly understand if it is too hypothetical. But as a representative of just the people who are trying to better understand this, there seem to be two possibilities for what was the immediate cause of the explosion.

One of them is that the flame came out of the bottom end of the solid rocket booster and burned a hole in the main tank. The other is that it caused the booster to fly in a skewed way and then the top of it crushed into the main tank.

Do you have an opinion at this stage as to which of those two events is more likely to turn out to have been the one which actually occurred?

Mr. ARMSTRONG. No, sir; I do not have an opinion at this point.

Senator GORE. Well, I can certainly understand that. Now, in the statement you made about the possibly flawed process, Mr. Secretary, there have been reports of heated arguments the night before the launch, during which the manufacturer of the solid rocket booster recommended against going ahead with the temperatures as cold as they were predicted to be during that night.

Is that a factor which led to your conclusion that there was a flaw in the process?

Mr. ROGERS. I told the chairman when I came up here that I do not want to get involved in those kind of speculative questions. If we are going to do our work properly, we cannot be forced to answer questions all along the line about what we are doing and what we think.

Now, I have said several times we will make all of these facts public in due course and in a proper way, and at the moment I am not going to answer any of those questions.

Senator GORE. Well, I understand your response and I will not press you too hard on it. But with all due respect, I do not believe that is a speculative question. You made a public statement about the possible flaw in the decisionmaking process, and there have been public press reports about heated arguments the night before, and I was just asking whether or not that was what you had in mind or whether it was something else.

Now, when you made the statement of a flaw, you recommended that the people involved in the decisionmaking process not be involved in the investigation inside NASA.

Mr. ROGERS. That is right.

Senator GORE. Now, some of those people are engineers who are most intimately familiar with the facts involved. Is that right or wrong?

Mr. ARMSTRONG. Certainly that is true, those most directly—perhaps that know the most about it. But as a matter of general accident investigation procedures as conducted by NASA, the Defense Department, the FAA, NTSB, whoever, it is a matter of common

practice to use people that were not directly involved in the chain of command leading to the accident, so that they are not put in the position of having to pass judgment on their own previous actions.

And I think that is a policy which over the years has been in good stead, and it seemed appropriate to place that kind of a restriction on this investigation as well.

Senator GORE. I do not necessarily disagree with the Commission's judgment on that score. I am concerned that the expertise of those individuals be available and be used within NASA.

Mr. ROGERS. It will. We have talked it over and it will be. We are not going to ask everybody to take a leave of absence. They are going to be there and they will be available to provide information. We just do not want them in the investigative process.

Senator GORE. Now, there have been a number of reports which to me as a lay person are frankly very disturbing. And they have to do with the memoranda inside NASA warning in very explicit and graphic terms what could happen if these O-rings failed, and spelling out the history of problems with these O-rings and recommending in very strong terms that something be done about it very quickly.

And yet it seems that nothing was done about it. Now, the question that raises for me is, has the Commission uncovered a lack of regard for flight safety in the procedures followed by NASA?

Mr. ROGERS. What is the question?

Senator GORE. Has the Commission uncovered a lack of regard for flight safety on the part of NASA?

Mr. ROGERS. Well, Senator, we are not going to make any conclusions of that kind now. We have just been in operation for 12 days, and I think it is unfair to keep asking us to draw that kind of conclusion.

Senator GORE. All right, thank you.

Thank you, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Mr. Secretary, let me try and see if I can work this out both ways. I totally understand your frustration.

Mr. ROGERS. It is not really frustration, and I do not feel frustrated at all. We will make all of the facts available. We will do what the President asked us to do and try to cooperate. We do not want to do it right now. I am not frustrated at all.

Senator ROCKEFELLER. Well, I am glad of that. I understand your frustration in having us pepper you with questions which you feel you are not in a position at this point to answer.

Mr. ROGERS. That is right.

Senator ROCKEFELLER. You have indicated that you are going to make available not only what you conclude, the conclusions of your investigation, but I would take from that that you are also going to make available what led you to those conclusions?

Mr. ROGERS. Absolutely.

Senator ROCKEFELLER. Which would imply all of the aspects of sensitive, semisensitive, personal, professional information that lead up to your conclusions now, and I understand that. I mean, here you are without staff, on duty 12 days, under a barrage of public attention, which you indeed are accustomed to, but few men would be.

On the other hand, our situation, and not unfairly, is that the President put out the Executive order. He did talk about the power vested in him as President of the United States, but he also included the Federal Advisory Committee Act in the same paragraph.

You have referred to the separation of powers, and you have done so and you have done so quite properly. But I have a feeling that the Federal Advisory Committee Act was put in there quite specifically. In other words, he could have just said "the power vested in me as President of the United States," period.

But he did not. He included this other part, in which there are references made to open meetings, and that information be disclosed to the public, and a variety of other things, which may or may not have bearing upon what you want.

But it does talk about in that particular act, the Federal Advisory Committee Act, responsibilities of congressional committees, and it does refer back to the Administrative Procedures Act, wherein it does talk about in one place agencies that might be likely to significantly frustrate implementation of a proposed agency's action.

Now, I am not a lawyer and I am not trying to make a Federal case here. I am trying to give a frustration from our point of view.

I would judge that it is going to take a long time to conclude your investigation. I mean, if you are going to get the physical evidence from the bottom of the ocean, if you decide that that is worthwhile and if the submarines are photographing it and indicate it is worthwhile, it is going to take a long time and it is going to be very expensive to get them up.

And then what do you have when you get them up? NASA is no longer investigating.

Mr. ROGERS. That is not true.

Senator ROCKEFELLER. Well, they are no longer investigating in the same way as they were before it is reposed with you.

Mr. ROGERS. No, no. They are investigating actively. The same people are doing what they have been doing, and they have been doing it very adequately. The only difference is that the people who were involved in the decisionmaking process are not responsible for the investigation.

The idea that somehow this has slowed down the process is inaccurate.

Senator ROCKEFELLER. But that is not my point. I am trying to lead to a point. I am not saying they are not investigating, but they are under a general jurisdiction, ably commanded by yourself and Mr. Armstrong—with which, incidentally, I fully approve. I think that was a wise and proper decision.

My concern is this. If it takes a long time to find out the evidence, for you to arrive at your conclusions, there is going to be a physical evidence problem, there is going to be—after the physical evidence is produced, if it does lead to a positive conclusion, if you can actually and finally say what it is that did happen, then there is going to be a very long leadtime of 18 to 24 months perhaps before anything else can happen in the way, for example, of the next launch.

One concern that we have here is trying to keep the NASA program a civilian program, and I am sure it is one of yours. Is it not possible—and this is not a question, but just a musing on my part,

not an amusing musing—that DOD, which always has priority on these matters—NASA's particular payloads are always the fourth and final part of payload rights on this. DOD is always the first one.

It is quite possible that DOD, the Air Force, will simply take this over, because the President has stated we have to have a space defense system in space by a certain time, talking about the midnineties and now perhaps later than that.

I think it is fair to say that the NASA program before this tragedy was losing popularity, it was losing money. It did not command the preemptive attention that the Apollo missions commanded. There is now much more question about the mix. There is much more competition. There is much more commercialization.

So from our point of view, it is not that we ask for information merely that it be given to all of the committee members, but only that in order to save NASA as a civilian program. With this long leadtime for the conclusion of the investigation and whatever it is that takes place after that, why would it be so impossible, in that the Federal Advisory Committee Act was specifically included by the President, to allow let us say a senior majority staff member or a senior minority staff member, and maybe only those two, to read—not to hold, but to read, not to sit in on the meetings but to read, testimony of what it is that you are getting, to help us?

Mr. ROGERS. Well, let us talk about that. We went through this with Senator Riegle. I do not want to be unreasonable.

On the other hand, we really do not want to open up our executive committee sessions because, for the reason that I mentioned. We will try to work with your committee. We have no interest in delaying anything. We will try to work it out somehow so we can have a procedure that is good for everybody.

God knows we do not want to disrupt anything. We are trying to help.

Senator ROCKEFELLER. As are we, Mr. Secretary. And I guess, Mr. Chairman, that would be my final comment. I think the purpose in this investigation is to, first, conclude what happened and to make sure that it does not happen again. But quite frankly, beyond that, from our point of view, it is to save the NASA program for the future and to make sure that it does not get swallowed up in a list of priorities with a diminishing budget under Gramm-Rudman.

And I think that is what Senator Riegle was trying to indicate, that we want to cooperate. If I were in your position, I would be doing exactly the same thing. But we do have budget considerations and we do have Gramm-Rudman. We have this program which has been diminishing in popularity. We need to save it.

And therefore, whatever possible cooperation there can be is, I think, vitally important for the future of NASA.

Mr. ROGERS. Well, I appreciate that, Senator. We will certainly consider that and we will try to help.

Mr. ARMSTRONG. I might add that we are trying to determine these causes and make our recommendations, and the Commission on the whole feels strongly that doing that job in the minimum possible time is in the interest of all Americans, and we are certainly going to do everything that we can to avoid any delay whatever in getting on with our job.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Senator GORTON. Senator Ford.

Senator FORD. Just a point or two, Mr. Secretary. I agree with you. I think the more faces and feet you have in a meeting, the more chances you have of something getting out that was misconstrued, and it might be more damaging to NASA for all of us to have this ongoing information. I hope you can find the answers.

You were very careful, and that was brought up by Senator Gore, in your opening statement that the process to the decision was flawed, not the decision. That is a little bit like going to a country church: You love the sinner, but hate the sin. And I wonder about that.

Those who made the decision apparently had to set up the decisionmaking process, and so, if those who made the decision also developed the process, would they not need to be looked at—or how they arrived at the process be one of your areas of concern?

Mr. ROGERS. Yes, sir.

Senator FORD. Now, Senator Rockefeller makes a very strong point that the space program is becoming routine, not as much interest in it as there has been in the past, and by having civilians fly on the shuttle, it brought more public attention to it.

And you say that one of your priorities is to determine how NASA's schedule and the desire to meet it affect the launch decision. So I hope that you will look at maybe the need for public awareness and public support that might have been an overriding factor in getting the launch off.

And Mr. Armstrong, my final question. How much awareness, or how aware were the seven people on the shuttle of what could happen? How were they briefed and what did they sign off on? Were they—did they understand the possibilities of what happened before they agreed to go? Did they know all of the possibilities?

Mr. ARMSTRONG. Senator, I will be exploring that area in substantial detail during the course of the Commission's work.

Senator FORD. Were you aware of all of this, then?

Mr. ARMSTRONG. I was going to add that, from my own experience, the crewmen knew full well the risks associated with their job. As a matter of fact, in my case, it always surprised me when things worked properly.

We expected a large number of equipment failures during the course of each flight. We spent all of our training focusing on how to handle emergencies of whatever nature, and we just hoped that we would never have to face the kind of emergency that we did not have a procedure to handle.

I cannot answer specifically the question about how these particular crewmen viewed that situation, but from my own experience and all of the people I know well and over the years I was in that position, we very much knew of the risks.

Senator FORD. Thank you, Mr. Chairman.

Senator GORTON. Thank you.

We are delighted to have Senator Goldwater with us, and I wonder if he has any questions or any comments.

Senator GOLDWATER. I would like to go on the next flight.

Senator GORTON. Thank you, Senator.

Mr. Armstrong, I have one additional question on a somewhat different subject. Assume that sensors and the computers were sophisticated enough to have determined in the first few seconds after launch, at the time of the first puff of smoke that you have now discovered, that there were serious anomalies which could very likely lead to this explosion.

Was there any possibility or is there any possibility under present configurations of separating the shuttle from the external tank and the solid rocket boosters for any kind of emergency landing before the solid rocket boosters are fully burned out?

Mr. ARMSTRONG. Not to my knowledge, Mr. Chairman. It is certainly possible that, were you to task our industry to build such a system, that they may be able to come up with it, with a configuration that could do that. But I do not know whether or not it would be technically practical to do so.

Senator GORTON. Well, I guess my first question was, it was not possible on this flight or under present configurations?

Mr. ARMSTRONG. No, sir; it was not possible, or it was not deemed to be survivable, sir.

Mr. ROGERS. I think the NASA officials said that there was no practical likelihood that anyone could survive in that case.

Senator GORTON. Is this a matter of enough interest to you to make recommendations of changes if it were technologically feasible in the future?

Mr. ARMSTRONG. It would certainly be considered by the Commission in the course of their deliberations.

Senator GORTON. Thank you very much.

Senator RIEGLE. Mr. Chairman, if I may, just a followup on your point.

It seems to me there is a difference between whether the shuttle could be detached and then its ability to survive once it was detached. Had there been a way to know that the sequence of events was happening, versus the belief of the technical people that if it had detached it probably could not survive for reasons of where it was and its ability to navigate by itself.

Mr. ROGERS. I think the answer to that we were given at the Commission hearing is it was probably not possible.

Senator RIEGLE. I am asking, I guess. I just want to make sure that I am hearing carefully enough what you are saying. I am asking the first part of the question and not the second. I am asking, was it possible for the shuttle to be detached if the information had gone through the loop fast enough?

Could the shuttle have been split off from the boosters, quite separate and apart from its ability then to maintain some kind of a flight path on its own? Could it have been separated if the system were in place to get the information to somebody who could have made that separation decision?

Mr. ARMSTRONG. I cannot answer the question, I am sorry. I will find out the answer to the question, however, because there are second and third order effects here that have to be considered, with which I am not familiar in sufficient technical detail.

Senator RIEGLE. Fair enough. So that remains a question mark at this point.

Senator GORTON. Senator Hollings.

Senator HOLLINGS. Secretary Rogers, has the Presidential Task Force given any instructions or whatever to NASA to arrest or in any way abandon their own investigation? And the reason I ask that is that Dr. Graham told the subcommittee last week in a prepared statement about his internal investigations, and he says, in our investigation to date, we have focused on so-and-so.

And then in the next paragraph, the investigation is focused on the physical evidence, and he talked about two internal investigatory groups, the data and design task force and the devil's advocate group. And now today in his prepared statement, which I am confident he will deliver here in just a few minutes, he talks about, in our review to date, and our review has focused.

And I get the inference that he is not investigating anymore, but he is reviewing. And I just wondered whether he has received any direction or guidance from the Presidential Commission that, look, we are making this investigation and anything you get you give to us, and let us not have any two investigations going on at the same time.

Mr. ROGERS. No. On the contrary, he has been very cooperative, and we just had a meeting with him this morning. I do not think anything has slowed down. The only thing we have is a statement that I made that, insofar as there were people in the decisionmaking process prior to the launch, that he ought to consider not having them on investigative teams.

Now, that is not going to slow down anything. There are not going to be a large number of people involved, and those people for the most part—I talked to some of them. They preferred not to be in a position where it appeared that they were investigating themselves. And so I do not think it is going to cause any change at all, except when we get information from NASA, whoever is in charge of that group will provide it, so that there is not any suspicion that we were not getting all of the facts.

Senator HOLLINGS. And you have no objection to his continuing with his internal investigation?

Mr. ROGERS. Not at all. It is very helpful to us.

Mr. ARMSTRONG. I think, Senator, to footnote that, that his investigation and our investigation are really the same, except from the purposes of the people that you say that are really doing the work.

Senator HOLLINGS. And once again, I hope you get your investigators on board, because Aviation Weekly will run circles around you if you do not. They seem to have a lot of gumshoes out there, and I do not know the reliability of it, but they are a pretty reliable group and they seem to have a lot of sources of information.

Mr. ARMSTRONG. Yes, sir. We are fortunate to have the past editor for 20-some years of Aviation Weekly on our Commission, and we think he has got a lot of access to some of those gumshoes that might be able to help us if we should desire it.

Senator HOLLINGS. Very good.

Senator GORTON. Gentlemen, thank you very, very much. We appreciate your help and we know we will be hearing from you again.

Dr. Graham and Mr. Moore and Mr. Winterhalter.

Dr. Graham, we are ready to hear from you and, if you wish, either of those accompanying you to make an opening statement, we will be happy to hear from them as well.

STATEMENT OF DR. WILLIAM R. GRAHAM, ACTING ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JESSE MOORE, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; AND DAVID WINTERHALTER, ACTING DIRECTOR, PROPULSION DIVISION, OFFICE OF SPACE FLIGHT

Dr. GRAHAM. Thank you, Senator Gorton. Mr. Chairman, distinguished members of the subcommittee:

The tragedy of January 28, when the *Challenger* was destroyed shortly after liftoff, reminds us in the cruelest possible way that the exploration and the exploitation of space is not without risk—risk not only to people and machines, but to the spirit to persevere in the face of adversity.

The greatest tragedy, however, would be if the loss of the *Challenger* and its crew would undermine our national will to solve the problems that have been presented, to confront new challenges, and to continue to open the frontiers of science and technology.

Our first priority has always been and will continue to be safe and successful shuttle flights. Prior to the mission on January 28, the U.S. manned space flight programs—Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz test project, and space shuttle—had completed 55 successful launches, carried 196 crew members into space, accumulated over 11,500 hours of flight time, and traveled over 170 million miles in space, without the loss of any human life during flight.

Understandably, our major energies today are currently absorbed in supporting the investigation of the 51-L accident. The President appointed the Presidential Commission on the Space Shuttle Challenger Accident on February 3, 1986, to review the circumstances surrounding the accident, to establish the probable cause or causes of the accident, to develop recommendations for corrective or other action based upon the Commission's findings and determinations, and to submit its final report to the President and to the NASA Administrator within 120 days.

The NASA participation is currently designated as the 51-L Data and Design Analysis Task Force. The task force charter, description of structure and membership are being prepared and will be provided in the near future.

In our review to date, we have focused on acquiring and consolidating all of the data related to the STS 51-L accident. To ensure that all of the data was preserved, we impounded all sources immediately following the accident. The data was then duplicated so that originals could be cataloged and preserved more completely.

The task was then to identify, catalog, and distribute the hundreds of thousands of pages of information, frames of photography, and so on to the proper location for more detailed analysis.

The review has focused on the physical evidence from salvage operations, on launch-related data analysis, including weather effects, on photographic evidence, integrated loads analysis, and the mission events time line, on the manufacturing and assembly processing of hardware, on the launch pad, on the cargo, and, I might add, on the design of hardware and operation, and many, many more factors.

No STS element has been excluded as a candidate prime cause. We are comparing all scenarios against the facts and discriminating between cause and effect. Both the solid rocket booster and the external tank are involved in these scenarios. At this point in time, information concerning the orbiter, shuttle main engines, and other elements are also being analyzed.

At this point in the data analysis, which is a very preliminary point, I underline, the orbiter itself appears to have functioned properly and to have responded to external factors.

The recovery of the floating debris from the accident has been nearly completed, but recovery of physical evidence from the ocean floor will be a time-consuming, laborious, and difficult task. First, the evidence must be located and mapped using detection equipment, some of it very sophisticated. Special vessels are required because of sea conditions, 3 to 4 knot currents at 1,100 to 1,200 feet in the Gulf Stream, where we are now searching and the depth of water in the vicinity of the debris.

Once a significant item is located, large submersibles will be used to photograph the item and the surrounding area without disturbing the evidence. And I emphasize that this is not a salvage operation in the classical sense. This is an evidence recovery operation, and therefore it must be handled in a much more precise and careful way.

These photos must then be studied to determine if and how the item is to be recovered. The weight of some of these items would be very substantial. The weight of the SRB, solid rocket booster for example, each is over 100,000 pounds.

The area where the debris is located now covers hundreds of square miles, and that is on the ocean floor. It is estimated that it will take a considerable period of time to locate and recover much of the evidence that is there.

Mr. Chairman, this ends my prepared testimony. I appreciate this opportunity to appear before you today, and after brief comments by Mr. Jesse Moore, seated to my right, who is the NASA Associate Administrator for Space Flight, and an introduction that he will give of the gentleman to his right, we would be pleased to answer any questions that you may have.

Senator GORTON. I wish Mr. Winterhalter would move the model so that I can see him.

Mr. MOORE. Mr. Chairman, members of the committee:

This is Mr. David Winterhalter. He is the Acting Director of our Propulsion Division in the Office of Space Flight.

Before answering your questions, sir, I would like to make just a short statement concerning this national tragedy. With the exception of the families of the *Challenger* astronauts, the seven brave men and women who gave their lives for the cause of reaching for the next frontier, space, no one feels any greater loss from this tragedy than the members of the space shuttle team.

I speak on behalf of the entire team, and I would like to say that we grieve every day. At the same time we are working at a feverish pace to analyze data and vigorously support the Presidential Commission that is investigating the 51-L mission tragedy. We must leave no stone unturned. We must maintain the resolve and dedication to find and repair our problems and once again with

confidence return to space safely and routinely with the space shuttle.

I am happy to answer any of your questions, Mr. Chairman.

Senator GORTON. Does Mr. Winterhalter have any statement?

Mr. MOORE. Mr. Winterhalter has no opening statement, sir.

Senator GORTON. I want to start my questions, Dr. Graham, not with the accident, which I will get back to, but with some of your preliminary thoughts about the future of the space program itself. We have seen reports in the press that NASA recently asked McDonnell Douglas for information about the purchase of 10 Delta expendable launch vehicles. Is NASA reconsidering the decision which it made a number of years ago to phase out the use of expendable launch vehicles? And if it were to go back into that business, for what kind of missions?

Dr. GRAHAM. Mr. Chairman, at this point in time NASA and the administration as a whole, through the interagency process, is considering the broadest possible range of options, including further use of expendable launch vehicles, which in a government sense of course, are not being phased out but are being continued by other agencies of the Government.

We are looking across a broad range of options and, since NASA has historically been the focal point for work on the McDonnell Douglas system that you referenced, the Delta, that is one of the options that we will consider. But I do not want to represent these as either-or options to the committee.

There will be, certainly, a shortfall in the national orbital launch capability in the near term. Both as an agency and as part of the Administration, certainly it behooves us to look across every possibility that we can identify to try to make up that shortfall and to try to make sure that we have a broad-based national space program.

Senator GORTON. When do you expect the senior interagency group on space to be in a position to make recommendations to the President?

Dr. GRAHAM. As you know, Mr. Chairman, that is a multiagency process, and its pace is determined by the magnitude of the issues involved, the degree of focus that the various agencies are able to establish in the time of the interagency group's activities.

Because of that, it would be presumptive of me to speculate on how long that process is going to take. However, from start to finish I know that the interagency group is making every effort to accelerate that process to the greatest degree possible.

Senator GORTON. But would it be safe to say that the subcommittee and its parent committee, and for that matter, the Congress of the United States, are going to have to make decisions on an authorization bill for NASA for fiscal year 1987 without those recommendations?

Dr. GRAHAM. Mr. Chairman, that is really a question at the determination of the interagency group and the Office of the Cabinet Affairs in the Cabinet, to which it reports, and the National Security Council, and I am not prepared to speak for them. I think they may, as they proceed, wish to consider possibilities in which they deal with the issues in factored sets, subsets of the overall problem, but groups of issues that seem to go together, and I am sure they

will make every effort to address the critical matters in as timely a manner as is humanly possible.

Senator GORTON. As you know, Dr. Graham, at the present time the priority order for shuttle payloads ranks Department of Defense payloads No. 1, foreign and commercial payloads No. 2, NASA and other Government payloads No. 3. As a result of the accident and the uncertainty of future shuttle schedules, and a smaller capacity for at least an extended period of time, is NASA in the process of reassessing that order of priorities?

Dr. GRAHAM. If I may, Mr. Chairman, I would state the order in a slightly different fashion. I would say that the first order of priority is national security payloads, payloads that are critical to our country's national security; second, critical NASA payloads and in some rare cases other payloads which have specific launch window constraints such as the Galileo and the Ulysses payloads which have an approximately 20-day window every 13 months during which the payloads can be launched on their missions to go to Jupiter. After that we have foreign and commercial payloads, and those in my mind are grouped together with the NASA scientific payloads and are traded off on at least an equal basis with each other.

I think as we have lost one quarter of our shuttle orbital capacity and are temporarily in a state of hiatus of shuttle flights, it behooves us to go back and review the entire launch manifest, all of the payloads, and to see what means we can identify to achieve the launch capabilities that we had hoped to achieve with the four orbiter fleet in as timely a way as possible. We will do that and consider all options in the process.

Senator GORTON. What about the pricing policy? We have come up with a $74 million pricing policy for fiscal year 1989, but that was based upon a launch rate of 24 missions a year.

Do you think it likely that the pricing policy will be altered?

Dr. GRAHAM. Again, Mr. Chairman, that was a pricing policy established through the interagency group and a Cabinet process, and it is not a NASA item to determine alone.

I am sure that will be considered along with the broad range of other activities as we go into the process. However, I believe the foundation for that was substantial when the decision was made, and if we consider it further, that should be our point of departure in those considerations.

Senator GORTON. Let me ask a question that I have asked in a slightly different form. In the the next 2 weeks or so, before we must consider in the full Commerce, Science, and Transportation Committee an authorization bill for fiscal year 1987, are you going to have any recommendations to us as to revisions in the NASA budget?

Dr. GRAHAM. I do not have a definitive answer on that at this point, Mr. Chairman. That depends upon the pace of the interagency group process, possibly on the pace of the Presidential Commission on the accident, and possibly other factors.

Senator GORTON. Finally, with respect to the future, when are you going to be able to advise us on your position on a replacement for *Challenger,* whether or not we should attempt to build a fourth orbiter?

Dr. GRAHAM. Mr. Chairman, my answer to that is the same as to the previous question. I think those two questions are very closely tied together, and while I cannot give you a specific date, please be assured that we are working on those issues as rapidly and as hard as we can, and in fact, within the NASA structure, I have established a separate task force which is not involved directly in the study of the accident and is not involved in the data analysis and design review but is focused entirely upon implications of the accident to our national space program. They are working that issue with equal speed and vigor to the analysis work that we are doing in support of the Presidential Commission's investigation.

Senator GORTON. Dr. Graham and/or Mr. Moore, I would like to ask you the question that I ended my questioning of the two members of the Commission, with the outstanding refinement which Senator Riegle placed on that, and that is, if you had been able to tell within a few seconds after launch that you had a disastrous launch which was going to end in that explosion, could you have separated the shuttle itself, the orbiter itself, from the external tank and the rockets; and second, if you could have done so, could it have escaped destruction in any event?

Dr. GRAHAM. That is a very complex question, Mr. Chairman. Let me start it, and perhaps Mr. Moore would like to add some information to it.

There exists a capability in the orbiter and at the command of either the pilot or the mission commander, through a sequence of steps, to remove the attachment of the orbiter to the external tank. That has to be done later, in any case, so that the orbiter can free itself from of the external tank. So, in that sense, it can mechanically be detached at that point.

There are additional attachments at the point where two 17-inch fuel lines, one providing liquid hydrogen to the main engines and one providing liquid oxygen to the main engines, carry those cryogenic fuels to the engines. The mechanics of those attachments are very complicated and involved, when detaching. The sequence involves the dynamics of the orbiter and the tank and the forces at that point. They were not designed, nor was the system designed to be detached during the 2 minutes and 8 seconds or so while the solid rocket boosters were operating at thrust and still attached to the external tank.

So while, in a detailed sense, the orbiter can be detached, there is a question as to whether in fact it would come cleanly free from the tank, and even if it did, whether with the thrust of the solid rocket boosters being applied to the tank, whether the dynamics would be such that the orbiter could depart the tank without some other damage or excessive stress occurring to it.

After that, of course, there is a question of even if it were able to free itself by some process, could it return to some landing base successfully. The bottom line on this, I believe, is that in the design of the shuttle system, neither the capability to assure that a successful detachment could occur or the training for such a detachment was included, because it was taken as a design requirement that the solid rocket boosters be so reliable that the orbiter would not have to detach itself from the external tank while the solid rocket boosters were still attached. Therefore, anything that I

could say now about that process, other than the mechanical statement that I gave you at the outset that you could blow those attachment points, would be very speculative. We are going back and looking at that, but at very best, I think we will find that it would be a very difficult process. That is a preliminary indication but consistent with the overall design philosophy of the shuttle system.

Mr. Moore, do you have anything to add?

Mr. MOORE. I think you have covered it very well, Dr. Graham, in terms of what past studies have shown and some of the earlier considerations in the program, in looking at ways to physically separate the orbiter from the external tank and solids, using some other mechanism. The program placed its emphasis on the reliability of the solid rocket boosters during this basic 2 minute-plus period, while the SRB's were at full thrust. And so I think you have answered that quite appropriately.

Senator GORTON. That is by far the most precise answer to that question that I have heard or seen. But I take it that at least implied in the answer to that question is further investigation of those possibilities and a further consideration as to whether this should be an alternative or an attempted alternative on future missions. Am I correct?

Dr. GRAHAM. Yes, sir.

Senator GORTON. On another subject, to what extent does the Commission's decision to exclude from the NASA investigation certain personnel who were involved in the launch decision impair the agency's ability to fulfill its own responsibilities in the investigation?

Dr. GRAHAM. Mr. Chairman, the principle here, as I understand from direct discussions with the Chairman of the Commission, Secretary Rogers, is that the Commission has requested that NASA personnel involved in various processes associated with the shuttle system, specifically the launch decisions, not be placed in a position where they would have to investigate themselves. I consider that a very sound position. It is something that NASA would have carried out even had we not been asked, and it in no way interferes with the NASA work either to understand what occurred or to support the Commission.

We will continue our investigating efforts and are working closely with the Commission, and that is just a principle of good management of any study such as this.

Senator GORTON. There have been public reports in the last few days that on the evening before the *Challenger* launch, Morton-Thiokol officials were emphatic in their advice not to launch because of the effect cold weather might have on the solid rocket booster seals.

Is this report consistent with your own findings, and have you been able to determine whether that in fact is the case, and if so, was it considered in the process of reaching a decision to launch?

Dr. GRAHAM. Mr. Chairman, that again is a very complex issue. What I would like to say about it is that I think it falls under the category generally of the question of NASA investigating itself and whether it should, in fact, be trying to make a specific determination on that. I think it far better that NASA make available to the Commission all information and all sources and all people, all

events associated with that, and other critical occurrences in the launch decision as well as in the design, the test, the qualification and the rest of the process that established and created the shuttle system, and that I would like to defer to the Commission to reach a conclusion and judgment on that matter.

Senator GORTON. And I take it in anticipation that that will be your answer to any other question of the sort that Senator Gore asked of the Commission members?

Dr. GRAHAM. If the question regards specific internal findings of matters of fact or technical characteristics or design characteristics, I will be only too pleased to answer you or to have my colleagues answer you. If it involves questions of procedures, or actions, or judgments taken by the NASA staff at various points, I think it would be far more productive to defer to the Commission on that because I believe that is one of the major reasons for which the Commission was established, and at the same time, if I do not, I put NASA in the position of basically attempting to judge itself.

Senator GORTON. Well, Dr. Graham, at least the first half of my previous question was simply a question of a matter of fact, and the qustion was, and I will shorten it, did Morton-Thiokol officials on the evening before the launch advise that the launch should be postponed because of the effect of cold weather on the seals?

Dr. GRAHAM. That unfortunately is not a question that I can give you a simple yes or no answer to. There were quite a number of officials involved and so on, and I do not wish to prejudge the situation. So I would really prefer, if I could, not to answer that simply because there is no simple answer.

Senator GORTON. Are we assured we are going to have an answer to that question within the foreseeable future, whether the answer is simple or not?

Dr. GRAHAM. Mr. Chairman, I would look to the Commission, and as I understood Chairman Rogers' response to you earlier, his response was that all relevant information concerning the *Challenger* accident would be provided to you at the appropriate time.

Senator GORTON. I think it is very important for NASA to understand, as I believe the Commission should understand, that given the nature of NASA's mission, which was designed in the first instance to operate in a goldfish bowl, and under full public scrutiny, in distinction to operations of the Department of Defense, that it is very important that factual questions like that be answered and be answered in a way which is quite clear not just to Members of the U.S. Senate and the Commission, but to the general public.

Dr. GRAHAM. Yes; sir. I understand that point very well and very strongly, and I believe Chairman Rogers and the Commission understand that very strongly. And I cannot today give you a clear, definitive and comprehensive answer to that question. But I am sure that one will be determined and established and provided through the course of the investigation.

Senator GORTON. Senator Riegle?

Senator RIEGLE. Thank you, Mr. Chairman.

I want to try to go through some things quickly.

We have had a chance to speak before about some of these matters in our other discussions. It seems to me that what you said about the system not being designed to separate off the shuttle in

that first 2 minutes in the event of a buildup of negative circumstance, that it then becomes all the more important to really nail down the safety features during that first two minutes and with the booster rockets. It sort of leads us back to this mounting concern about whether those rockets were designed properly, whether these O-rings were as good as they should have been, whether the cold temperatures might have aggravated a problem in that area, and the fact that this had been redflagged. In other words, there is enough data now in the record that indicates that the O-ring problem, if you will, was one that was talked about, looked at, identified as a problem and needing some work. It seems to me that what you have just said is that because of the important reliance during that first 2 minutes or so of launch, that that becomes even more critical.

I understand that at the launch site when people were going around with gauges and reading the temperatures on the booster rockets, that apparently before the launch there was a finding that down at the lower part of the rockets the temperatures were very low. They were down, say, at 10 degrees or less, is that right?

Dr. GRAHAM. Senator Riegle, there were measurements made at approximately 7:30 in the morning with an infrared pyrometer, an optical infrared instrument to read the temperature of a number of points both on and off the flight hardware, including the solid rocket booster. There were temperatures that were indicated on the instrument which were in the 7-to-9 °F. range. However, let me caution you very carefully that infrared pyrometers making that reading are not easy instruments to operate, and we are working very hard to establish the error bounds on those measurements. And I caution you that the error bounds could be quite substantial, and until we determine what those are, I cannot tell you how high the temperature might have been or how low the temperature might have been at various points. We are working on that problem.

Mr. MOORE. Senator Riegle, may I add a little bit? As part of our routine preparation for launch, we always send ice teams out. That is part of the ritual that we go through in validating that the system is safe from an ice standpoint. Their primary objective is to look at ice formation on the external tank, or ice on the launch support structure which may impact things like the thermal protection system on the orbiter, and damage there could cause us some heat damage during our ascent flight.

On this particular occasion the ice team was sent out three different times, at 1:30 in the morning and at 7 a.m. Dr. Graham just reported to you on the data that they observed during that period of time, and also at 11 o'clock the ice team was sent out. Their primary purpose was to go out and physically look at the ice on the tank, physically look at any ice on the support structures to determine if we had a major problem or a major risk, I should say, associated with ice debris which may impact the thermal protection system. That is what they basically reported back to the launch team.

Senator RIEGLE. Well, as I understand it, though, when they used this infrared device—and I assume that is the best device we have. I mean, I assume if it was not, they would be using something

else—as I understand it, higher up on the tank the temperatures were higher, the temperatures were up in the 20-degree-plus range, and for some reason, at least the readings they got as they got down to the bottom of the tank; there was this anomaly of the much lower temperature; is that correct?

Dr. GRAHAM. The readings at the lower part of the tank showed a lower temperature, Senator Riegle. I caution you though to let us add the uncertainty bounds of that instrument reading and that geometry before you reach a definitive conclusion as to what the temperatures might have actually been.

Senator RIEGLE. I understand that point.

Now, in terms of how that information gets transmitted up the line or across to the decision launch team, as I understand it, apparently that information did not make its way through a chain of some sort to the small group at the top that actually was responsible for the launch decision, is that right?

Mr. MOORE. That is, I think, a correct assessment as we understand it right now, but again, the ice team reported that we had really no problems on the orbiter thermal protection system or from the launch support structure with respect to ice on the structure, impact or the tile on the orbiter. There was a special meeting held, that our level II program manager held with representatives from the various elements of the program to assess that, and at that point in time their assessment from an ice standpoint was that we were safe.

Now, what specifically happened relative to temperatures getting up and how far they got up the system is something, Senator, that we are looking at right now.

Senator RIEGLE. Let me ask you this, Mr. Moore. Were you a member of that launch decision team?

Mr. MOORE. Yes, sir.

Senator RIEGLE. If you had gotten that information ahead of time that the lower part of the booster rockets were showing temperatures below 10 degrees, would that have caused you to have a material concern?

Mr. MOORE. Well, it is hard to say. You know, hindsight is 20/20.

Senator RIEGLE. I understand. We are trying to reconstruct. It is all 20/20 now.

Mr. MOORE. I understand that, and I would say that if any of my project people or my level II managers and so forth had some issues, that those are in the philosophy of a shuttle program raised and discussed very, very vigorously and very openly until they all surface up and people are completely satisfied that the flight is safe to launch.

Senator RIEGLE. Had you known that though, I mean, now knowing it and looking backward, is a temperature reading that low on the tank something that would have caused you a high sense of alarm or you would have said, look, I need to know more about this before we take any more steps?

Mr. MOORE. I believe I would have asked some more questions about what the readings indicated and what were the differentials between the left booster reading and the right booster reading and so forth were the kind of things that I would have put back down in the system to get some answers to.

Senator RIEGLE. Now, am I right in understanding that in terms of temperature parameters, that 31 degrees was supposed to be sort of the lowest level of temperature, and below that——

Mr. MOORE. Sir, we have in the space shuttle program, back from its early days, as I recall the history, and I have been in the program since I think February 1983, but in the early days of the program we had a launch commit criteria, which is basically a red line in the program, that said if the ambient temperature is not greater than 26 degrees, we do not launch, and that was in the early days of the program, some years ago. And my memory escapes me in terms of the precise time. That was updated to say if we do not have an ambient temperature which is 31 degrees or greater, we do not launch, and at the time of this particular launch, that was considered the ambient launch temperature, or the ambient temperature at launch was 38 degrees at the time of launch.

So that is the major constraint we have relative to the launch commit criteria.

Senator RIEGLE. I have just got one other question at this time because there are a hundred questions that one could ask with respect to the business of the O-rings and the temperature and the procedures and so forth.

Who are the members that serve on that launch decision group? How big a group is that? Yourself and how many others?

Mr. MOORE. Let me give you a minute or two, if I might, in terms of how NASA prepares to get ready for launch and who then are the players involved in that launch preparation.

We start out by having each contractor who contributes a major piece of hardware or software to the program to conduct their own internal review to their own management. That review is then reported to the responsible NASA center flight team. For example, in the case of the SRB, if we want to take that, Thiokol would do a review. They would then come to the Marshall Space Flight Center at the Marshall project level and review that review with them. Then the Marshall SRB project people would then go to their center director and review that with them. Then it would go to the Johnson Space Flight Center where our program management resides at what we call our level II. They would then conduct an integrated review across the program. That review would then be brought to my level where me, my managers like Mr. Winterhalter, my deputies and others, would sit and listen to the issues associated with a particular launch, and in the case of this process, decisions are then made at the various levels. I mean, they are made at the contractor level, the engineering level.

Senator RIEGLE. Let me just ask you this. Say within the last hour before the launch the small group of principals, the top level executives, yourself and the others, how small would that final group be after they had gotten all of this input that really has to sort of make that collective judgment that say go or no go?

Mr. MOORE. We have in our launch control center there two basic areas that have about six or seven Kennedy Space Center people in it, and the Kennedy Space Center has the responsibility for the launch processing and the preparations for launch up until about 31 seconds, and then after the 31 second count, we go into an

automated sequence, and then it lifts off, and the Johnson Space Center then flies that.

And so we have got six or seven Kennedy people there as part of the overall launch team. We also have as part of the launch team about seven or eight other critical people sitting in the launch control center, including myself, including the center director from the Marshall Space Flight Center, including the project director for the solid rocket booster, including my level II managers from Houston, Mr. Aldrich, including his deputy, Mr. Kohrs. And so you have got a tiering again of people there that tag up on a loop constantly. There is a voice loop going on at the launch control center trying to make sure everything is coming together, and any problems that occur during the countdown are in fact heard by everyone and discussed by everyone.

And in addition to the real people, the people that are actually sitting at the launch control center, there is an entire flight team of people at the Johnson Space Center that are listening and interacting on these conversations to ensure that any issues that might affect the flight are in fact raised and discussed.

And one final thing, we bring up operation centers at the Marshall Space Flight Center in Huntsville as well. There are a lot of people both from the Marshall Space Flight Center and the contractors that support the Marshall Center and their propulsion system products are actively also listening in on these particular activities, so that there is a large network of people that is pulled together to ensure that if any issue comes up during the countdown of a flight or our preparations for a flight, that issue can be handled in real time.

Dr. GRAHAM. Senator, just to add one point, NASA doesn't launch by a vote of 10 to 2 or something like that. It is unanimous with all the people on the loop before a launch, and people well down in the system can go through a designated chain when the process is operating properly to put their view forward.

Senator RIEGLE. I just wanted to have for the record, were you in that final launch loop yourself on this flight?

Dr. GRAHAM. No, Senator, I was not. I have been there on previous launches. I was there in the anticipation of the launch on Sunday, but that, as you know, was canceled Saturday night because of the anticipated poor weather. I returned to Washington, and Mr. Philip Culbertson, the General Manager of NASA, went down to the Kennedy Space Center and was there through the following days and through the launch.

However, while he or I represent a senior management presence there, in general, and while we monitor the process that Mr. Moore describes, in general practice, as a matter of most occasions, we do not inject ourselves in that process.

Senator RIEGLE. Mr. Chairman, I am about to yield in the interests of time because it is late and we have other colleagues who want to question, but I am wondering if I might inquire of you if we know yet when we might reconvene to try to continue on in this general line of inquiry.

Senator GORTON. I do not have a precise date in mind, but we will reconvene. We are going to have another hearing on this sub-

ject, and we will have as many as are needed to satisfy our inquiries and to take our responsibilities seriously.

Senator RIEGLE. And I ask that question because it is clear I think from the questioning that has gone on so far that we are beginning the discussion, but there is an awful lot that we are going to have to talk through, and to get finally, and hopefully sooner rather than later, to some of these operational decisions we are going to have to make together, and they are enormous. I do not know that the public yet understands the nature of the new policy choices and decisions that are now imposed on us by this accident and all of the demands that are pressing in from different directions, quite separate and apart from the investigative effort to find the problem and solve the problems, which we are going to do.

But we have got a lot of work ahead of us, but I think we have made a good start today, Mr. Chairman.

Senator GORTON. Thank you.

Senator Hollings.

Senator HOLLINGS. Thank you, Mr. Chairman.

Dr. Graham, can you think of any information which you would give the Presidential Commission that you would not give to this committee?

Dr. GRAHAM. Senator, I understand that is a very careful question, and I would like to give you a very careful answer to it.

I think there may be some legal areas that would fall under that type of condition, and I am an engineer, not a lawyer by training, and if you will permit me, I would like to respond to you to that question carefully in writing in a prompt way.

Senator HOLLINGS. Well, I do not see the complication, and I do not see the need to be a lawyer to answer that particular question. This is the oversight committee for the National Aeronautics and Space Administration, and bluntly, there is an old saying that whose bread I eat, his song I sing. Mr. Moore and I are both from South Carolina, and I have studied my humility under Mendel Rivers.

And I do not intend to sit here on this committee and not necessarily upstage the Commission. We are not trying to do that. But at the same time, I do not like the Commission to be used to answer the questions of this committee, because it is our responsibility ultimately. The President has appointed his Commission, but the people have appointed us, and we will be around longer than 120 days. Right to the point, we have not only got your authorization, I am on the appropriations end and the budget end. I get you three ways.

And so I want answers to my questions.

Now, No. 1, is there any information that you can think of that you would give to the Commission and not give to this committee?

Dr. GRAHAM. Senator Hollings, at this point in time there is nothing that I can think of that would fall under that restriction. However, I must tell you that I do not consider that to be a comprehensive answer, and I will get you a comprehensive answer to that as soon as possible.

Senator HOLLINGS. Well, I am a little surprised at your hesitation, and particularly your answer with respect to the Morton-Thiokol opposition to launch.

Now, is there not any evidence that you know of to support that report?

Dr. GRAHAM. Senator, I want to make sure I understand which report you mean.

Senator HOLLINGS. The report that Morton-Thiokol the evening before unanimously opposed the launch and so advised NASA. Is there any evidence to support that report?

Dr. GRAHAM. No, Senator, the evidence is in the other direction.

Senator HOLLINGS. There is no evidence whatsoever to support it as far as you know?

Dr. GRAHAM. That is right, Senator. However, let me say that again that that was a very complex process which occurred over a substantial period of time, and I am very concerned about trying to give you a yes or a no answer that describes the situation which will become apparent, I am sure, as time goes on and it's not yet fully apparent to me or to NASA, nor do I believe to the Commission, and which will have many aspects to it that go beyond a simple yes or no.

Senator HOLLINGS. Well, the time involved is just the evening before, and I do not understand the complexity, and whether or not you have got any support for that. I mean, as far as you are concerned, that is a rumor and there is no basis in fact for that particular report?

Dr. GRAHAM. Well, Senator, at the end of that process the Morton-Thiokol Co. provided a statement signed by a member of their senior management who normally signs for them, recommending that from their perspective the shuttle launch proceed, and that is at that point the end of a complex process which I am not able to fully characterize to you today, but that is at least one piece of evidence which I have seen.

Now, I do not want to imply that that in any way characterizes the entire process or what occurred, but that does exist.

Senator HOLLINGS. I see.

With respect to the significance of the change in the presentation, where your prepared statement said on Friday, you used the terminology "investigation," and now you are talking about a review, is there any significance to that, Dr. Graham?

I have the two statements here, and I noticed the identical wording except you are talking about review instead of investigation.

Am I reading something into that, or did someone say stop investigating, there is only one investigation, and that is the Presidential Commission, and as far as the agency is concerned, or the administration, there is not any investigation going on?

What is the case? What is the situation?

Dr. GRAHAM. Senator Hollings, I think the concern is between the notion of an investigation which is a generic term for a study and analysis or review and so on, and a search for the facts on the one hand, and the investigation on the other hand. There is one comprehensive investigation of the *Challenger* accident. It will provide one report which will be submitted to me and to the President, and of course, I am sure, to the Congress, and it will be the definitive investigation of the *Challenger* accident, and that will be conducted at Presidential direction by Chairman Rogers, and the Presidential Commission, that is the investigation. NASA is conducting

analysis of data, establishment of technical facts, establishment of the entire chain of design, test, qualification, manufacture, quality control, transport, assembly, checkout and so on activities, that led to the launch of the *Challenger*. We will continue to pursue that. We are pursuing that as an agency at this very moment, with the utmost vigor. Nothing has been done in any way to impede that process nor, I am assured by Chairman Rogers, will anything be done to impede that process.

But I do not want to give you the impression that NASA is itself conducting the complete, comprehensive, unbiased study or investigation of the subject. That must necessarily in this case be done by the Presidential Commission, and as I understand it, that is their task.

Senator HOLLINGS. I understand.

Mr. Moore, with respect to the responsibility of the ice team, that had no responsibility, as I understand, with respect to the innards of the solid rocket booster? In other words, they were looking for external ice that might flake off and hurt the particular exterior of the shuttle itself?

Mr. MOORE. Yes, sir.

Senator HOLLINGS. Like you and I know, you can have an indication of only 7 degrees, you can have a wind chill factor, and while it has gone up to, let's say, 38 you say at the time of launch, it still could have caused a crack, perhaps, of that putty-like substance in there.

Mr. MOORE. Possibly.

Senator HOLLINGS. Are you looking into that?

Mr. MOORE. Yes, sir. As Chairman Rogers said earlier, Senator Hollings, we are looking at all aspects of the weather. We are looking not only at the temperature effects and how the temperature varies as a function of time during that area, but we are also looking at the relative humidity, and it was a particularly, as I recall from my memory, a fairly dry evening in Florida, and so we had fairly low relative humidity. We are also looking at the amount of rain the shuttle system was exposed to during its time on the launch pad. During the middle of January in Florida, we had an enormous amount of rain down there. There was something like 4 or 5 inches in a very short period of time, and we are not sure that rain had any effects on the launch or on the system, but that is another aspect that is being looked at as far as weather.

And the other aspect from a weather standpoint is we are looking at the winds. We are looking at the upper atmospheric winds, because if you have seen the time line that came out, where we have tried to quantify the various events that took place during this flight, at somewhere around 59 to 60 seconds, it looks like we get a fairly significant side force, and that could be a wind sheer. Prior to launch, we used weather balloons that we send up on a very frequent basis to get a measure of the upper atmospheric winds to determine the loads on the vehicle as it is going up through its ascent trajectory, and prior to launch we had a clean bill of health from the load standpoint. But postlaunch there was some weather activity reported in the area, and we are now trying to trace that to see if that had any effect upon *Challenger's* flight.

So in summary, we are looking at all aspects of the weather, temperature, the wind chill, and the profile of the temperature. We are looking at these readings that we had between the right hand and the left hand and the external tank, the right hand and left hand booster and the tank, and trying to understand the whole perspective associated with the weather on that evening.

Senator HOLLINGS. And if, as you say now, with the decision to launch that had been delayed, that had been out on the launch pad for how many days?

Mr. MOORE. That particular vehicle, I think, Senator Hollings, was on the launch pad since I believe the 22d or 23d of December, in that period of time. We had planned to launch it on the 25th of January as we got closer into the January timeframe, and we had planned to launch on the 26th. That evening we decided to scrub the launch attempt on the 26th because of rain forecast the next day. We got a forecast that said there is almost no chance of having any opportunity to launch the next morning. As it turned out we did have some opportunity to launch on the next morning, but we scrubbed on the basis of the forecast the evening before.

Then the next day we scrubbed our launch attempt on Monday because of cross winds at the runway in the event we had to get into an abort mode of the shuttle. We do have cross wind limits which are kind of launch commit criteria, as I described earlier, and they were very, very high at that time. So we did not press on with the launch then.

And following that scrub, we then went into a meeting in the afternoon to talk about should we prepare for launch the next day. And at that time we got a weather forecast, and the weather indicated that yes, it is going to be fairly cold in Florida, in the mid-20's, but we had a 3-hour launch window, and none of our senior managers in that meeting expressed any real concerns about preparing for launch the next day.

So we left the session with all system managers of the tank and the solids and the orbiter all going back and preparing for launch the next day, and if there were any problems with the launch, they were to report back in to our management structure and let us know so we would hold the launch.

Senator HOLLINGS. If the freeze had actually cracked the putty-like substance around the O-rings, there was no check during that month's period to actually check one way or another?

Mr. MOORE. No, sir; to my knowledge there were no checks on the putty. The putty, part of the joints, is made at the factory. The nozzle joints are made at the factory. And from an O-ring standpoint, we had seen most of the occurrences in the nozzle area from an O-ring erosion standpoint, we had had very little problem with the case joint, and the case joint is the system that is put together vertically at the Kennedy Space Center. Putty is laid upon the joint, two O-rings are put around the particular segment. Then it is lifted together, tang into a clevis. And then we put 177 pins around the circumference of each individual segment and put a band on that segment and tighten the band up and put a rimming of cork around that particular band, and then it is painted with a thermal coating on it, and that is how we made that particular segment.

We build all those segments up until we get a complete rocket.

Senator HOLLINGS. And those segments indicated in your inspection that even with all of that caution that there had been some breaches of that O-ring?

Mr. MOORE. We had seen on the field joints I think about six instances out of the entire flight experience on the field joints, which are these joints here. There is a joint there, there is one there, one here, and I believe one up there, there are three joints, approximately here up to here, and we call them field joints. They are made at the Kennedy Space Center. In other words, the segments are shipped to the Kennedy Space Center from Utah. They are then mated and stacked at the Kennedy Space Center, and we had seen I believe six instances on the primary seal where we had seen some minor erosion of the primary seal on those case joints, but never any erosion of the secondary seal. And in the putty that is used to put these joints together could have had some indentation due to temperature exposure and so forth that we may have had some cracking of the putty, but we do not know that for a fact, Senator.

The other thing I would like to comment on is that there has been a lot of speculation that the O-ring is the problem. We are not sure the O-ring is the problem. As I am sure you know, too, we do see as we reported and as the media has reported, a cloud of black smoke emanating from the right SRB, in this vicinity here.

Senator HOLLINGS. So it had to come from the O-ring?

Mr. MOORE. We are not sure it had to come out of the O-ring.

Senator HOLLINGS. What other potential is there?

Mr. MOORE. You could potentially have something erroneous or anomalous, I could say, with the strap here possibly. There is also a leak test port that we test these O-rings as we put these segments together. There are two O-rings. There is a leak test port that we check the pressure and seat the O-ring with about 200-pounds-per-square-inch pressure. If that port had some anomaly associated with it or problem, we could possibly get a leak through that. You also could postulate the possibility of maybe some hole in the external tank showing some liquid hydrogen impinging on there and possibly igniting some of the grease that is around these case joints here.

And so there are a number of scenarios that we are looking at there. The O-ring certainly is one of our primary options at this point in time, but we just do not want to rule out the possibility that there are some other areas we are looking at.

Senator HOLLINGS. Well, you see what the committee is getting at. In other words, with all of the delays and getting behind and so many launches to be accomplished there in 1986, and so whether or not we were a little too hasty and did not show the proper caution, that is what we are really looking at also, in addition to the mechanical failures that could have occurred.

Thank you, sir.

Thank you, Mr. Chairman.

Senator GORTON. Senator Gore.

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

I want to pursue the orbiter matter, but before doing so, I just wanted to pin down this Thiokol business because your response earlier to Senator Hollings, Dr. Graham, is just diametrically op-

posed to what the published accounts have been, and that happens from time to time, but I would like to explore it a little bit further.

Now, Mr. Moore, did you have any conversations with Thiokol the night before the launch?

Mr. MOORE. No, sir, I did not. The last conversation, as I recall, with Thiokol was at the launch minus 1 readiness review which was held on Saturday morning at 11 o'clock.

Senator GORE. The picture I get, and you tell me if I am wrong, the picture I get is that the Thiokol people expressed concern, and during subsequent conversations between NASA and Thiokol, eventually Thiokol signed off and said, well, OK.

Is that an accurate description of what happened?

Dr. GRAHAM. I think, Senator Gore, it is necessarily an incomplete description of what happened, and to that extent, not accurate.

Senator GORE. As far as you know, is it accurate, and supplement it with details that you think are essential to improve the committee's understanding.

Dr. GRAHAM. Unfortunately, I really do not feel that I can give you a description of that entire process which would supplement and make accurate the committee's understanding of that process at this point because, as I stated earlier, I do not believe any one person fully understands the process that occurred.

Senator GORE. Well, just do the best you can, Dr. Graham, just from what you know. Just give us the best information that you personally have about it.

Dr. GRAHAM. Senator, it would put me in a position of almost certainly leaving out vital and important elements of it, and therefore necessarily misleading you and the members of the committee.

Senator GORE. Is your understanding of it consistent with the description I just gave?

Dr. GRAHAM. No, sir. As I stated earlier, my understanding of it is the process was more complex and involved than that, but I do not have a complete understanding of it.

Senator GORE. In what ways does your understanding of it differ from the way that I gave you?

Dr. GRAHAM. My understanding of it, Senator Gore, was that the process involved more complexity, more activities, more discussions.

Senator GORE. Did they initially express reservations about a decision to go ahead at those temperatures?

Dr. GRAHAM. Who, Senator?

Senator GORE. Thiokol.

Dr. GRAHAM. There was obviously concern by Thiokol, yes, sir.

Senator GORE. All right.

Subsequently there were discussions between NASA and Thiokol.

Dr. GRAHAM. Yes, sir.

Senator GORE. After that time, Thiokol eventually signed off on the decision to go ahead, is that your understanding?

Dr. GRAHAM. Yes, sir.

Senator GORE. Mr. Moore, is that your understanding of what happened?

Mr. MOORE. Yes, sir.

Senator GORE. Is there something left out of that description that would make it more complete?

Mr. MOORE. Senator Gore, as I think Dr. Graham has indicated, this was a complex matter. I was not personally involved in that particular discussion, but I think the steps that you outlined there are in fact the set of circumstances that did occur. There was some discussion at Thiokol. There was discussion between Thiokol and the NASA people at the Marshall Space Flight Center, and in the final analysis, the Thiokol management signed off on a recommendation to launch.

Senator GORE. Thiokol communicated through a written wire, is that correct?

Mr. MOORE. My understanding is, sir, there was a telephone telecon, as we call it, set up between the people at the Kennedy Space Center representing the Marshall Space Flight Center.

Senator GORE. Is it a voice link?

Mr. MOORE. It is a voice link, and some people are meeting and so forth, and so there was a mixture of personal, person-to-person meetings as well as telephone meetings, but the final product, as I understand it, was a datafax piece of paper that had the signature on it that Thiokol supported the launch.

Senator GORE. I see.

Can you provide that to the subcommittee?

Mr. MOORE. Yes, sir.

[The following information was subsequently received for the record:]

MTI ASSESSMENT OF TEMPERATURE CONCERN ON SRM-25 (51L) LAUNCH

- CALCULATIONS SHOW THAT SRM-25 O-RINGS WILL BE 20° COLDER THAN SRM-15 O-RINGS
- TEMPERATURE DATA NOT CONCLUSIVE ON PREDICTING PRIMARY O-RING BLOW-BY
- ENGINEERING ASSESSMENT IS THAT:
  - COLDER O-RINGS WILL HAVE INCREASED EFFECTIVE DUROMETER ("HARDER")
  - "HARDER" O-RINGS WILL TAKE LONGER TO "SEAT"
    - MORE GAS MAY PASS PRIMARY O-RING BEFORE THE PRIMARY SEAL SEATS (RELATIVE TO SRM-15)
      - DEMONSTRATED SEALING THRESHOLD IS 3 TIMES GREATER THAN 0.038" EROSION EXPERIENCED ON SRM-15
    - IF THE PRIMARY SEAL DOES NOT SEAT, THE SECONDARY SEAL WILL SEAT
      - PRESSURE WILL GET TO SECONDARY SEAL BEFORE THE METAL PARTS ROTATE
        - O-RING PRESSURE LEAK CHECK PLACES SECONDARY SEAL IN OUTBOARD POSITION WHICH MINIMIZES SEALING TIME
- MTI RECOMMENDS STS-51L LAUNCH PROCEED ON 28 JANUARY 1986
  - SRM-25 WILL NOT BE SIGNIFICANTLY DIFFERENT FROM SRM-15

JOE C. KILMINSTER, VICE PRESIDENT
SPACE BOOSTER PROGRAMS

MORTON THIOKOL, INC.
Wasatch Division

INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

Senator GORE. All right, fine.

Let me preface this question by saying, Dr. Graham, that NASA has had the image of being just foolproof; I mean not foolproof but just so dedicated to quality control and perfection and all of that, and everybody is concerned that a tragedy of this kind not needlessly destroy an image of that kind that has been built up, and I, like all members of the subcommittee, want to be careful in that regard.

I must say that it is difficult in reading the published news reports over the last week or so to sustain that kind of image. It really is, because just to take the example of the O-rings as the leading example of what seems to have been—I want to use the word mishandled, because from my point of view, it seems that some of the memos in NASA files should have raised all kinds of red flags and warning bells, set off warning bells, and yet they did not.

As early as December 17, 1982, the O-rings were identified as a potential problem and put on the critical items list. Then there was a whole series of studies and investigations of what might be going wrong with these things, and then in April—well, there were several incidents where the first of the two O-rings failed, and the soot blew through, and then in April 1985, the second one in the nozzle area also suffered a partial failure. At that point, one of the engineers was quoted as saying, "that is when I started getting scared."

Do you remember that memo?

Mr. MOORE. I do.

Senator GORE. Then a couple of months later, we have the budget, the document from the budget analyst who—and it was quoted in the paper. You know the one I am talking about?

Mr. MOORE. I know the one you are talking about——

Senator GORE. Maybe it is nct fair to go back and dig something like that out of the files and say, gosh, anybody reading that should have done more to prevent this from happening, a potentially major prcblem affecting both flight safety and program cost. Then you have the finding of the report of the SRM handling ring mishap investigation board which, in finding No. 3, says, test team lacked discipline. Then you have the incident with the gantry hitting the external tank, and finally they had a problem with a bolt, and they brought the instrument up and the battery failed, a small thing.

But then, all of these things seem to add up to the fact that something has gone wrong with the absolute commitment to quality control and discipline that we have always come to associate with NASA.

Now, is that unfair to reach that conclusion?

Dr. GRAHAM. Well, Senator Gore, there is no question but that a tragic accident took place with the *Challenger,* and there is no question whatsoever that that accident should not have taken place. If history is any guide, as we understand what caused that accident, and history of far less complex systems than the space shuttle system, we will in fact eventually find that there were a large number of events which occurred in sequence, virtually any one of which, had it been done differently, would have prevented the accident.

The structure of those events is something that the Presidential Commission is certainly working, beginning it work to discover, and NASA is providing its full support to discover. In the process of operating a system as complex as this, with human beings, there are bound to be points where actions are taken, where activities are conducted which are not perfection. In fact, one of the design criteria is that the system can be operated by humans.

There is obviously something that has not gone correctly in that process, and we intend to find it, we intend to correct it, and we intend to not let it happen again.

Senator GORE. Who is in charge at NASA, Dr. Graham?

Dr. GRAHAM. I am, Senator Gore.

Senator GORE. Is Dr. Beggs still in? Is he still—does he still come in to work every day?

Dr. GRAHAM. Senator Gore, I have not seen Mr. Beggs come in to work every day.

Senator GORE. Do you know in fact that he has been coming to work or not?

Dr. GRAHAM. I don't know, in fact, but I have not seen him coming to work for several weeks.

Senator GORE. You have not seen him with your eyes.

Have you seen other evidence that he has been at work on a regular basis?

Dr. GRAHAM. No, sir.

Senator GORE. Has he left you notes?

Dr. GRAHAM. No, sir. I have seen him there, or it was reported that he was there once in the past 2 weeks, I believe.

Senator GORE. Was he there the day—and let me preface this by saying that I do not want a cheap inference on this question, I really do not, but let me just say what I was told, that on many occasions, including the day of the accident, he comes in and leaves written tasks for people, including you, and then you get them, and you do not see him personally but you get the task.

Is that right or wrong?

Dr. GRAHAM. That is inaccurate, Senator Gore. Mr. Beggs, to my knowledge, has never left a written task for me.

Senator GORE. For others?

Dr. GRAHAM. I do not know, Senator. Not to my knowledge.

Senator GORE. You have not heard that?

Dr. GRAHAM. No, sir.

Senator GORE. Mr. Moore, do you want to respond to that?

Mr. MOORE. I would like to comment, Senator Gore, on two factors. One is the safety aspects, the question you raised earlier about NASA being lax on safety. I think NASA has a very excellent safety record. I think we have got a very, very rigorous process which starts out with a set of directed documentation that goes down through each of our NASA field centers and to our contractors requiring them to maintain quality safety standards in all of the products they produce for us. These are products that are manufactured or inspected not only by the contractor but also by Government inspectors, and they are bought off at each step along the way. We have safety offices that are very, very active, in addition to each contractor, at each NASA center that is manufacturing hardware for the shuttle. We also have a major office on safety, reliability, and quality assurance at the Johnson Space Center that is especially set up and established, just to look at overall safety, reliability and quality assurances for the shuttle flights, as far as the shuttle flights are concerned, and we also have the NASA Chief Engineer's office here in Washington that has a specific set of functions assigned to it in the areas of safety, reliability, and quality assurance.

So I would like to respond back to your comment by saying I think NASA does an extremely thorough process in looking at safety. There can be human processes somewhere along the way that are not according to the book, and that is what we have to go back and really try to find. In the case of the KSC activities that you cited, Senator, I would like to say that I think we have monitored that transition. You know, Lockheed took over the shuttle processing contractor some 2 to 3 years ago, and in the process, following that transition, I think the overall incident record, the overall safety record has been very, very good down at the Kennedy Space Center, and I think that marriage has worked very well between KSC and the Lockheed Corp.

Senator GORE. Let me just say in conclusion that I have a number of questions on quality control for our future space shuttle budget hearing. If I had time today, I would go into what appears to me to be a reduction in the number of quality control people. I understand there is a difference in the job definitions and all of that, but I will deal with this matter at a future hearing.

In conclusion, I wanted to explain the reason why I asked the questions about Dr. Beggs not being fully gone and still sort of there but on leave and so forth. I think that in almost any organization there is a tone that affects what everybody does. If there is some kind of confusion at the top, uncertainty, then I think that can have an effect on an organization. I see it in departments and offices all the time.

I believe that NASA needs a full-time Administrator, not an Acting Administrator, but an Administrator who can take the helm and set that kind of tone that is going to be so critically needed in the aftermath of this very difficult tragedy for NASA and for the country.

Did you want to respond to that? My time may be up.

Mr. MOORE. I would like to make one more comment. You left an impression earlier, Senator, about the program not responding to the O-ring situation. I would like to make two comments. One is in the joint in question, on this particular flight, which is the case-to-case joint, the worst case O-ring erosion was only the primary erosion, and it was on flight No. 2 in the Shuttle Program back in November 1981.

Point No. 2 I would like to make is that we were clearly concerned about erosion. My engineers, the Marshall engineers, the Thiokol engineers, felt we had an adequate margin of safety for flight, and yet we initiated activities early last year to start out on a test program and a potential redesign program to correct even the erosion we were seeing. But in our experiences to date, we still maintained on the secondary O-ring, the only time we saw erosion on the secondary O-ring, we maintained a factor of four safety on that O-ring. Tests were done in the laboratories which demonstrated we could stand a factor of three to four more erosion on the secondary O-ring and still be in a safe condition.

NASA took very active, very aggressive actions, in my opinion. It was looked at by a lot of engineering people, not only in my office, but a lot of engineering people at the Marshall Space Flight Center, some outside engineering people as well as the contractor engineering people, and we felt we were on a prudent course of action as far as correcting what erosion we were seeing in the program.

We were not happy with that. Let me conclude with that.

Senator GORE. Mr. Chairman, I would like to add just one thing that I think ought to be part of this session, too. I am told that in the category of things which could cause a catastrophic loss of the mission into which the O-ring problem fell, there are more than 700 other items.

Now, I think—excuse me—over 700 other criticality I items, and the reason I raise that is that you go back after one of these things and pick one out which is suspect, and I did want to put that in perspective. Still, having said that, I think that the record on this particular issue is one that really calls into question the way in which the alarm bells are heard and rung.

Thank you.

Mr. MOORE. Senator Gore, let me respond on that. In fact, there are more than 900 criticality I items. If you take each individual item one at a time and counted through the systems, they are ele-

ments such as primary structure, structural elements that have to be integral and proper in their strength and their installation and their maintenance and so on, and they go through a very, very broad range of equipment. That is a large number, but if you were to take a commercial air transport, you would also find a very large number of items which were category 1, where it is in fact essential to the operation of the system.

The important thing, in our view, is to identify those clearly, understand their importance, and make sure in the engineering and manufacture and quality control test and checkout and so on that they are in fact capable of performing the role necessary for category 1 items.

If I may respond to your earlier question about NASA management, let me assure you that from the moment that I became the Acting Administrator, when Mr. Beggs stepped aside, there was never any question whatsoever in my mind, nor do I believe in the mind of the NASA staff, who was in charge of the agency and who was the designated President's appointee to be in charge of NASA, and that is still the case today, Senator.

Senator GORE. Thank you, Mr. Chairman.

Senator GORTON. Senator Rockefeller?

Senator ROCKEFELLER. You indicated that NASA is a part of the investigation. Secretary Rogers indicated that was also the case. There is some evidence to the contrary as to how that is to be described. At a meeting this morning with some staff members, you indicated that it really was the Presidential Commission who is doing the investigation, but that probably is not the main point.

I am concerned about the future of NASA as are you. You are Acting Administrator. You have in 1985 a $7½ billion budget. It went up a little bit in fiscal 1986, and then Gramm-Rudman chopped $300 million off. So it is now actually less than it was in fiscal year 1985. You have budgetary pressures, you have military objectives in space pressures, you have Ariane pressures with respect to what the Europeans are doing. You have the problem that I indicated earlier of a somewhat diminished public fascination prior to this tragedy with NASA, and hence the whole budgetary crisis under the Gramm-Rudman discipline that we live under.

My question to you is that in answers to specific questions today, whereas you were much more forthcoming than Secretary Rogers, you still needed to deflect a lot because if your investigation comes underneath his, then there is still a question of what you can tell us.

We are in the process of trying to make a budget. The subcommittee has to recommend to the full committee. We have to be in final response on a budget recommendation by April 1, which is 5 or 6 weeks off.

Are you wearing two hats here? Are you going to be able to advocate as you would ordinarily to us, and argue with us over budget priorities and what we need to be looking at, or are you locked in until this investigation is concluded?

And let me just redefine that. What comes out of the investigation could be expensive. It could cause us to do things that we might not otherwise do in our budget. If the O-rings are a possibility, there are at least 40 possible options for correcting that, sealing

problems, external tank problems, solid rocket problems, putty problems, additional sensor problems which add to the weight of the load, and therefore cut down on what can go into the shuttle. All of these cost.

We have budget decisions to make. Are you in a position to be able to advocate for your agency what you want to see us put into that budget in the next 6 weeks so that we can come to a conclusion, or are you locked in until this whole investigation is complete and cannot be forthcoming with us?

Dr. GRAHAM. Senator Rockefeller, to address your first point first, I would like to distinguish between the investigation which is the Presidential Commission's mission, its charter and its goal, and those activities supporting that investigation which NASA is necessarily conducting and will bear much of the load on. The activities in support of the Presidential Commission in my estimate will involve many tens of thousands of work-hours of activity to understand what happened, why it happened, and how to correct it and how to make sure that it does not happen again, and we are certainly very actively pursuing that in NASA.

But NASA will not provide the conclusive report either to the Congress or to the President. The Presidential Commission will provide that, and I think there is a clear separation in responsibilities there. And I believe I have tried to make that clear this morning, and I will be glad to elaborate further if you wish.

As far as budget priorities go, the fiscal year 1987 budget that NASA prepared and you have received was prepared before the *Challenger* accident. It was done with no anticipation of the *Challenger* accident, and, therefore, it is not entirely applicable to the post-*Challenger* accident situation. There are activities that we had planned for fiscal year 1987 and in fact for 1986 which cannot now be undertaken. There are activities which had not been contemplated at the time of that budget which might appropriately be undertaken. We have all of that under review, and we will do everything that is possible to bring forward to you a budget and a plan of action that is appropriate to the era we are now in, which is the post-*Challenger* accident era. That much I can assure you.

Senator ROCKEFELLER. This much I can assure you, then. This particular Senator wants to see the continued success of NASA. This particular Senator does not want to see the Department of Defense take advantage without castigating them in motivation of this tragedy in order to absorb the NASA Program. I see that as a distinct possibility, given the long leadtimes, the budget crisis, Gramm-Rudman, the length of the investigation and what might come up after that. I hope that I see you in a position where you will be able to advocate, we will be able to respond, we will be able to keep this program going so that it keeps its balance, so that cancer can be cured, so that the anemia can be cured, so that diabetes can be cured. It is not all military; it is not all satellites. I mean, the welfare of mankind is a very large subject.

We want to be supportive of you, and we hope and assume that you will be forthcoming with us as we deliver the budget product for your agency.

Dr. GRAHAM. Senator Rockefeller, we will certainly be forthcoming with you. We will tell you all of our assumptions, consider-

ations, constraints, how we construct the budget. We, of course, are under, as are all of the agencies of the Government, very close budgetary constraints. The DOD I believe bears half of the Gramm-Rudman cut for this year. They are under tight budgetary constraints.

Senator ROCKEFELLER. But not nearly like you are, sir.

Dr. GRAHAM. They in fact reimburse NASA for launch services that NASA provides, so that within their budget are funds which are tranferred to NASA for NASA resources that are provided to them, and, of course, that will continue. We will lay all of that out in great detail for you and everything will be on the table, Senator Rockefeller.

Senator GORTON. Senator, your statement was both relevant and eloquent.

I want to thank the three of you for coming today. This is, of course, not an easy task for you by any means. You have learned, however, that we are only at a preliminary stage of this inquiry, just as you are, and that all of the questions which have been asked here by one member or another are going to have to be answered eventually, and I hope as quickly as possible so that we can move forward with a strengthening of the entire NASA Program.

[Whereupon, at 5:15 p.m., the subcommittee recessed, subject to the call of the Chair.]

ROGERS COMMISSION REPORT

TUESDAY, JUNE 10, 1986

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

The subcommittee met, pursuant to notice, at 2 p.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the committee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Senate Subcommittee on Science, Technology, and Space. As we consider the report of the Rogers Commission on the *Challenger* disaster, I want to begin by formally expressing my thanks, and I am convinced the thanks not just of the subcommittee but of the entire Senate, to Chairman Rogers and to Vice Chairman Armstrong and to the members and the staff of the Rogers Commission.

As I have already stated, I believe that the work of this Commission will stand as an example for future such Presidential Commissions for many years to come. The combination of the competence and experience and background of the members of the Commission, who not only knew what to look for but how to find it, with their personal commitment to spend their own time on the investigation, rather than simply to respond, as so many blue ribbon commissions do, to the work of professional staff, have combined to produce a report which meets fully and completely the charge of the President of the United States to the members of the Commission.

In fact, here today I am not entirely certain what the members of the Commission and its distinguished executive director, Dr. Keel, can add. It seems to me that it is up to us, the Members of the Senate who have received this report, to hear whatever additional wisdom the two members here can provide, and then to engage in the much longer and more difficult pursuits.

The first of those pursuits is of course the oversight of NASA itself, and it will be up to us and our compatriots in the House of Representatives, as well as in the administration, to attempt to see to it that NASA promptly and completely and effectively carries out the recommendations which the Commission has made or has a very good reason, in particular cases, for not doing so.

Second, of course, it is up to us in the very near future to begin making decisions as to the mission and future of NASA. Do we build a replacement orbiter? What about a space station? Should we begin to plan toward the President's recommendation of an

aerospace plane? To what extent should we lessen our dependence on the shuttle and go back to a balanced program in which many missions are conducted by unmanned spacecraft?

Many of these questions were beyond the charge to your Commission, Secretary Rogers. But they are the charge of this committee.

Today we thank you for a job well done and we ask you, to the extent you are able to do so, to continue to provide us with your wisdom in the future.

To the end that we should hear as much as we possibly can from the members, I would like to announce in advance that I hope members will restrict their opening statements to 5 minutes each. We will have 10 minute rounds of questioning, but will not cut members off on one round. But given the fact that the report of the Commission is in written form, I would—I have every hope that we can complete that questioning today and go on very promptly to what is going to be the more important set of questions, those for NASA about its response to this Commission report.

Senator Rockefeller.

OPENING STATEMENT BY SENATOR ROCKEFELLER

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Along with the rest of the committee, I want to thank you, Secretary Rogers, Mr. Armstrong, Dr. Keel, and other members of the Rogers Commission for a truly extraordinary service to the country. I think your personal involvement and the intense commitment to finding the facts out and bringing them honestly, fairly, openly before the American public is exemplary and in the highest traditions of our Nation.

If I might say so, I think that the Rogers Commission exercise in response to the *Challenger* disaster is quintessentially American. That is, that you have faced openly and forthrightly the bad news and the difficult facts, and you have made no attempt to sweep anything under the rug, easy or tempting though perhaps that might have been to some.

As Justice Brandeis once said, sunlight is the best disinfectant. And when I compare what it is that we as a nation and you as a Commission have done in response to the *Challenger* shuttle crisis on the one hand in comparison with the way the Soviets have handled the Chernobyl disaster on the other hand, I think it is a lesson which should not be lost on this world, because I think it truly reflects the fundamental difference between our two societies and the integrity and the way in which we go openly and honestly at national dilemmas.

So I am deeply grateful to you. I have comments that I would like to make, but I will make those a matter of the public record, Secretary Rogers, because I will be interested in what you have to say, sir.

And please, please understand how grateful we are. When you first came before this committee, there was not any clear reason to me why it was that you had to do this. You have done so much in so many ways for our country.

There was a lot of dissension and questions at first, but there is not that dissension now, because I think through the symbol of the strength of your character and the quality of the folks that you have worked with people know that they have been given the truth. And when Americans know they have been dealt with truthfully, they will respond aggressively and positively.

We have got to get back to the business of putting NASA and the space program back on its feet, and we have got to do it intelligently, we have got to do it wisely. We cannot retreat from this national commitment and we cannot be afraid of what it is that you have reported in your report.

So I congratulate you, sir.

Senator GORTON. Chairman Danforth.

OPENING STATEMENT BY THE CHAIRMAN

The CHAIRMAN. Secretary Rogers, I want to add my word of thanks to you and the members of the Commission for a splendid job. I have not had an opportunity to explore in depth the Commission's report. I have just looked through it very briefly. I can assure you that the Commerce Committee will give it very close attention.

Your Commission has indeed served as a model for what a Presidential Commission should be. The time that you and your members put into this personally is greater than anyone would have expected—and, as you have stated, this is not a staff draft that was rubber stamped by Commission members. Each of you went into it personally in very great depth, at great sacrifice of your time and energies.

And I simply want to add my words of thanks to you. Your work has now ended. I hope you get a little rest.

Our work really has begun. I think all along there has been a question on the part of the members of our committee as to what is the precise role of the Commerce Committee, what is the precise role of the Commission. I have never felt that our job was to try to duplicate what the Commission was doing.

I do feel, however, that our role is going to be very important in the future, obviously, with respect to making decisions about the future of NASA, the expenditure of money for the space program, the oversight of the space program. We are going to have to take a careful look at your recommendations.

We are going to have to decide if there are any questions that are left open that we will have to explore. And with respect to the recommendations that you have made, we will analyze them and we will proceed to attempt to implement through legislation, or otherwise, those recommendations which you have made.

It really is a first-rate job. I just want to emphasize one final point, and that is the same final point which you have made in your Commission report. This has been a tragic time for the people who have been involved and their families. It has been a very despondent time for NASA. But I, and I think every member of this committee, completely share the confidence that you have and the members of your Commission have stated in NASA's future and in the future of our space program.

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When tragedies occur, and when errors occur, they must be corrected. But that in no way means that the basic mission of the space program has somehow reached its end. It has not. We are confident in the future of NASA. Your role has served to make it even sounder and better, and now the ball is in our court to do the same.

Mr. ROGERS. Thank you very much.

Senator GORTON. Senator Ford.

OPENING STATEMENT BY SENATOR FORD

Senator FORD. Thank you, Mr. Chairman.

I think all of us feel the same, and we probably put it in different verbiage. But I too, Mr. Chairman and vice chairman, believe that you have set the criteria for commissions in the future. You have pinpointed the problem. You have made your recommendations, and then I think probably the strongest point that you made in the whole report was your concluding thought, that NASA has brought greatness and from this we need to gather our strength.

And I just say to this committee and those that are here, I hope that we the Congress can equal the same level of competence and wind up with the same level of confidence that your Commission has given this country. I compliment you and thank you.

Senator GORTON. Senator Trible.

OPENING STATEMENT BY SENATOR TRIBLE

Senator TRIBLE. Mr. Chairman, thank you.

I too want to join my colleagues in not only welcoming Mr. Rogers and his colleagues today, but in thanking each of you for your leadership and for your thorough and thoughtful review of the problems that have plagued NASA to date, and your worthy recommendations.

I would like to think, Mr. Chairman, that we can now begin to turn the corner. We have this body of information and recommendations before us. We have new leadership at NASA. I hope we can begin to put these problems behind us and press ahead with vision and renewed vigor.

And I thank you, gentlemen and ladies on your Commission, for your contribution.

Senator GORTON. Senator Hollings.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Mr. Secretary, I also want to join in and thank you and the Commission members. I do not know of a more outstanding group of Americans assembled on a Commission. You have worked hard and we appreciate very, very much your working within the timeframe and coming up very early with this particular report.

I have a slightly different approach with respect to safety and the improvement of our performance out there at NASA. I find so far—I am studying the report and getting into the backup documents—that there was almost a zeal to make certain individual responsibility was not fixed. I do not find any individual found responsible.

It is not my zeal, as some have talked about, to suggest criminal negligence. I am not looking for criminal charges—I do not think there was any venality. But I do think when you fix the responsibility, thereupon you promote safety.

If every time one of these kind of things occurs and no one is responsible, you can put in 12 more safety commissions, 8 more review boards, and 9 more other safety groups, and if there is no responsibility to it, it won't be safe. I just feel someone should be accountable and there has been an indication to me that there has been. However, I hope you will respond to this approach and elaborate in your testimony.

But that is just a difference that I have in approaching this thing. I want to make absolutely certain that we don't have another disaster. Also I am glad to see that your report agrees with two remarks I made in February. No. 1, you finally agreed that it was an avoidable accident; and No. 2, the space program is still in the R&D stage and is not an operational, commercial-type program.

As your report indicates, there were some safety procedures. That's another area where you and I differ a little. You say that the process was flawed. I find the process and safety procedures violated. And that is where my questions will be coming from today. I do not intend to be hostile to you or anyone else on the Commission, but to really get at the heart of the issue, because we are putting in another process and if the new process similarly will be violated in the future, then we have made no real progress.

But I think if we make them know down at NASA that they are going to be held responsible, then we will have a fine, safe program that we all want to continue for the future in space for America.

Senator GORTON. Senator Gore.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Mr. Chairman, I know it is redundant, but I feel like saying it anyway. To you, Secretary Rogers and Vice Chairman Armstrong, Executive Director Dr. Keel, and through you to all of the other members of the Commission: It is hard for us as members of this statement to adequately convey to you the depth of appreciation felt by the American people for the work you have done.

The countless hours of personal time, the tremendous effort that you put in personally, rather than, as is often the case, just turning it over to an appointed staff, really was one of the most impressive jobs in my memory in looking at commissions of this kind and in the memory of those who have been watching them longer than I have as well.

So the only thing I would say by way of opening is, thank you for a demonstration of patriotism of the highest order in buckling down and really getting to work on an important task that was entrusted to you and doing it in an excellent fashion.

So thank you.

Senator GORTON. I have an opening statement from Senator Pressler for the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR PRESSLER

Mr. Chairman, we have now reached the end of a long, and at times, painful journey that began exactly 19 weeks ago today with the tragic loss of the Space Shuttle Challenger. During those intervening weeks, the President's Commission investigating the causes of the Challenger accident has conducted an exhaustive inquiry under the able leadership of its chairman, William Rogers.

Before we begin our discussion of the Commission's specific findings and recommendations, I think it appropriate to express our extreme gratitude to Chairman Rogers, Vice-Chairman Armstrong, Executive Director Keel, and all the other members of the Commission. These individuals have demonstrated the finest qualities of public servants by responding to the President's request for assistance and devoting countless hours to the Commission's work at the expense of their normal activities.

The Commission has carried out an extensive examination of the events leading up to the Challenger tragedy. Many of their findings have been, quite frankly, disconcerting. It is obvious that the communication and management processes which NASA developed and implemented for the Shuttle Program were inadequate.

The decentralized shuttle management system was inadequate to ensure that crucial information concerning the reliability of particular shuttle components and systems was brought to the attention of those ultimately responsible for the safety and lives of the flight crew. At the same time, the safety criteria designed to ensure the flight-worthiness of the shuttle were routinely waived, with ultimately tragic results. Yet, the existence of these failings within NASA are not reason for us to abandon the Space Shuttle Program, or any of our unmanned programs.

I mentioned earlier that we have reached the end of a long journey, but our work is far from complete. The next step is to correct NASA's problems so that we can renew our manned exploration of the worlds around us. The Commission's findings should not be used as a reason to end, or in any way diminish, the United States' commitment to manned space flight. Continued shuttle flights are necessary if the United States wants to maintain its preeminence in space science and technology. Manned flights are needed for launching and servicing satellites, conducting experiments that are impossible on earth, and developing medicines and materials that can be used here on earth.

This is not to suggest that we should rely exclusively on the shuttle for access to space. The series of rocket failures that followed the shuttle accident have clearly demonstrated that we must always have several operational systems capable of launching the communications, weather, and military satellites that are so crucial to our commerce, safety, and national security. For that reason, it is imperative that we begin the process of correcting those parts of NASA's structure that are broken. Congress, in conjunction with NASA, must examine and implement the recommendations of the President's Commission, and do so in a manner that will make our space program as safe and reliable as possible.

Senator GORTON. Secretary Rogers, if you would like to make any response or any opening statement. And if Mr. Armstrong or Dr. Keel would, too, we would be delighted to hear from you.

STATEMENT OF HON. WILLIAM P. ROGERS, CHAIRMAN, PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE "CHALLENGER" ACCIDENT, ACCOMPANIED BY NEIL A. ARMSTRONG, VICE CHAIRMAN; AND DR. AL KEEL, EXECUTIVE DIRECTOR

Mr. ROGERS. I sort of hate to have you stop.

Well, first let me say that we and the Commission appreciate very much the attitude of this committee. You have very patiently waited until we completed our work. You have made a lot of public comments in support of our work, and we appreciate that very much.

We appreciate the cooperation we have had from your staff, and we will continue to provide on our side the same kind of cooperation. We have thousands and thousands of documents that are available.

We are going to print further documents and appendices, which will come along in a couple of weeks. We could not get them all

printed on time because it is quite a printing job. Dr. Keel has an elaborate documentation system, which will become a permanent record of the nation, and it will be in the Archives and it will be automated so that it will be easy to retrieve any documents that the committee would like to obtain.

I think everything is, as you said, Mr. Chairman, in your opening remarks, everything that we have to say we have said in this report. We have tried to say it completely and thoroughly, without undue emphasis on any portion of it.

I think when one reads the whole report the impact is really quite great. It is sad in a lot of ways, but it is there. As Senator Rockefeller pointed out, I think it is in the best of American tradition. When we make a mistake, we admit it and present all the facts, so the public understands what happened, and make recommendations about how it can be improved in the future and then get on about our business.

That is what we have tried to do here in this report, and I hope that it will stand the test of time. I do not believe there is any doubt at all about what happened. Unlike the Warren Commission, where there continued to be doubt, I think this report is convincing to anyone who thoroughly reads it that this joint failed and that is what caused the accident.

Fortunately, they even found the very part or the portion that failed, which corresponds to the puff of smoke initially, which corresponds to the flame. And without doubt that is what failed, and that is what caused the accident.

Then we point out in the report other factors that contributed to the accident. We point out that there is a long history that should have signaled to the people involved that there was trouble with this joint and it is a major, major problem.

Everybody recognized early on there was a major problem. The segmented joints were a problem when they thought about it. There was debate at the time whether this was the best kind of a system, whether other systems were preferable, and so there was no lack of warning, it seems to the Commission. We call that chapter an accident rooted in history, because we think the history of it clearly shows that this accident was bound to happen unless something was done about it.

We point out that the safety system that was in place just did not work and, as Senator Hollings pointed out, there did not seem to be an adequate person in charge of safety, and that is what, one of the reasons we recommended, Senator, that there be a person assistant to the administrator who will be in charge of safety.

It will be his responsibility, and if things go wrong we can look to him if there are failures, failures in notification and communication.

Now, as some people have said—I heard someone on television last night point out that: Well, there was a reluctance to have one person in charge of safety, because everybody had to be in charge of safety. Well, that's true, in a sense everybody has to be conscious of safety. But if you leave it to everybody, what happens is it ends up really nobody being in charge.

I think in a sense that is what happened here, so that one of our recommendations, to address Senator Hollings' point, is that some-

one be placed in charge, as that will be his sole responsibility, to consider all safety aspects, so that any sign of weakness or failure, anything of that kind should go to his—immediately be called to his attention, so that he will know all aspects of it.

Yesterday, to digress just for a moment, we met with Jim Fletcher and Dick Truly, Admiral Truly, and he pointed out, which I thought was extremely significant and I had not heard about it before—I guess I did not associate him with that flight, but it underscores the importance of what we say in this report.

He was on the second flight, STS-2, and on that flight they had problems with this joint. He told me yesterday that he did not—he had never heard of the problem they had on his flight until after the accident, after we started talking to him about it.

Now, that obviously underscores what we have said in this report. That cannot happen again. We may have accidents in the future or with the program, but they cannot be based on lack of information. If we decide to take a chance and say there is nothing that we can do about this, but we have to go ahead with the program even though it is risky, at least that is a judgment based upon known facts.

But we cannot permit a system to operate where the people that make the decisions state they did not know anything about it. You will see in our report that we have a chart here of key people who say they did not know anything about this.

So we hope very much that this report will make everyone alert to really the importance of safety. We cannot consider this operational, we cannot consider it routine. Every flight has to be looked at with safety in mind.

We also recommend a safety panel which will be—and Neil Armstrong can explain it better than I, but it will be on the ground. It will involve astronauts and others, and they will be able to step in at any time, based upon any concerns they have, and stop a launch or make it impossible for the launch to occur.

This is one of the things the astronauts themselves very much wanted. We think that will be a very useful recommendation. It does not require any outside help and it does not require any money.

It is just, there was something similar in the Apollo Program which seemed to work pretty well, and we hope it will. So we have emphasized the safety feature of this to a great extent.

So there are two aspects that I wanted to emphasize in closing these few remarks, and one is, there is no doubt about it what happened, no doubt that this joint failed, and that was the cause of the accident. There is no doubt there were management failures and human failures in addition to the mechanical failure, and we hope that the recommendations we made will reduce the risks on any future flights.

One other point I would make is that we realize now that we finished our work, the difficult problems that this committee is going to be faced with. As you said, Mr. Chairman, there are extremely difficult problems. We have not undertaken to try to make any recommendations because we were not asked to; and second, I am not sure we were capable enough to do it.

We have not taken a position on the fourth orbiter. We do take the position that there are other safety matters, though, that should be considered and dealt with right away. And while the shuttle is not flying is a good time to fix some of these other things.

As you know, we listened very carefully to the astronauts and the astronaut community, and we think the astronauts should play a more active role in the space program. There are very few astronauts in management now and we recommend that they be considered a source of, or a reservoir of, extraordinary talent, so they can move into management.

We also recommend that they be given a more active voice in these launch matters. They have had an office and it has been a good office, but they have not been given quite the important place in the organizational structure of NASA that they should be. And I think Jim Fletcher will do that.

I think that as a nation we all have to get behind NASA. We all have to get behind Jim Fletcher and Admiral Truly and others.

I might say, Admiral Truly has been a very strong person in the picture. He has cooperated fully with us. He is highly respected in the community, not only among astronauts but everyone else in the system, and he is going to be in charge of this program in the future and I think he will be a great asset.

We are very fortunate to have him in that position.

Certainly we believe the headquarters here has to be strengthened. Apropos of Senator Hollings' point, at the present time, at the time of the accident there was one man who was on the organizational chart responsible for safety, and his name was Milton Silveira. He is the chief engineer, and his responsibility was safety but he had all kinds of other responsibilities.

He said, when we questioned him, "If I had known, I'm sure that any time period when we first came to the conclusion that the seal was not redundant", and that means that it was critical, and if it failed it was the loss of mission and crew, "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 knew nothing about this. He was the man in charge of safety, and he did not know all of this history that went on about the seal.

So we do believe that it is very important to have one man who is in charge of safety who is going to be responsible for the whole system. Now, it is not easy to get that kind of a man who is willing to do that. It does not have that glamour. You are going to be charged with a tremendous responsibility and a lot of good people, engineers and so forth, would rather do other things.

Anyway, I guess in conclusion I would like to say that we appreciate the support of this committee. We hope that NASA gets back and does a good job. We have every reason to think that they will. Now that we have finished our work, we will do all we can to support NASA.

Anything like this is very difficult for the whole organization. You can say maybe they deserve it, but most people in NASA have done a wonderful job. We know that. This was a failure of the system and maybe a failure of certain individuals. Having said

that, I am not sure that we gain anything by attempting to assess blame.

I agree with Senator Hollings. I do not believe there was any venality. I do not believe there would be any advantage to even thinking about a criminal case against anybody. I think it would be destructive. In any event, we did not go into that, but that is my personal opinion. I hope that we can just get on with the program and make it successful in the years ahead.

Thank you.

[The statement follows:]

STATEMENT OF HON. WILLIAM P. ROGERS, CHAIRMAN, PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE "CHALLENGER" ACCIDENT

Mr. Chairman, I would like to begin by expressing my gratitude and appreciation to you and your Committee for your support and cooperation thorughout 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 Commissions. 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 INVESTIGATON

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 interveweed 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 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 unbaised investigation of the Challenger accident, announced the formation of the Commission on February 3, 1986. The mandate given by the President, contained in Executives 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 Commisison'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 written 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 Commisison.

"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 produciton 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, particu-

larly 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 as-

sembled 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 cause membrane, or propellant anomalies were not the cause of the accident.

In contrast, joint seal failure was suspect. Enhanced photographical 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 related to O-ring pressure actuation timing and O-ring erosion.

The Commission concluded that the joint/seal design is 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 0.17 and .029 inches at the secondary and primary O-rings, respectively.

(6) A compresseed O-ring at 75 degrees Fahrenheit it 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 consequently 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 are 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.

The 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 sig-

nificant 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 cerfification 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 related 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 Mashall 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 progam made a conscious decision to postpone spare parts procurements in favor of budget items of preceived 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 lauch mission 51-L might have been subject 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 the 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 not 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 dramtically 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 alternative 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 concervative 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 budegetary 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 paramenters 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 inadvertent 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 obviously 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 treatey 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-fight "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 of 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 brough 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 Critically 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 to 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 Spece 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.

Senator GORTON. Mr. Armstrong.

Mr. ARMSTRONG. I want to thank you all very much for your kind words about our work. I recall that immediately after appointment, we sat in this chamber with this committee, and you gave us some very good advice. You said something to the effect of following the mandate of our Commission that the President gave us. You said something further, and I cannot recall which of the Members made a comment. They said, "and go where the investigation leads you."

That is what we have done. We did find the cause of the accident. We identified that clearly and, I think, without question. In the process of that pursuit, we did find some other things that are of interest, and the Commission has included those things where the pursuit, where the investigation, led us. We have included those things in our report.

At the same time, we would not want this committee or anyone else to think that we carried out a comprehensive evaluation of the technical, managerial, budgetary, or other aspects of the shuttle program. We certainly went where the investigation led us, and time did not permit us to go further.

We do believe, however, that if the recommendations that we have listed are carried out, it will certainly improve the chances of the success of the program to come.

Thank you very much.

Mr. ROGERS. Could I just add to that? I certainly agree with what Neil has said. When we started out, we did not know for sure what caused the accident, although we suspected it was the joint. We felt in order to investigate the whole system and to be sure that there was no contributing failure, we did look at all aspects or most of the aspects of the shuttle system.

In doing that, we found other areas that we thought deserved to be considered, and we have referred to those in the report. That is particularly true of tires and brakes, landing areas, and some other things. So Neil is right; we did not consider everything, but we did expand our mandate a little bit to make other references which I think will be helpful both to NASA and to this committee, and you will see those in the report.

Senator GORTON. Secretary Rogers, your very last comment leads to my first question, which in one sense is out of order. From the day of the accident itself, I have been very interested in whether or not there is any usable escape mechanism available for astronauts in the case of this kind of failure or any other kind of failure.

You have addressed that question in the report and in your recommendations, but the principal thrust of your recommendations in this connection is that NASA should make every possible effort to devise a crew escape system for use during controlled gliding flight which seems quite clear to rule on escape from the kind of accident which you investigated.

Is it the implication of your findings and your recommendations that there is no practical way to provide an escape for astronauts in an accident of this nature, even if the telemetry had been able to show just exactly from the time of launch that this was going to be the result?

Mr. ROGERS. I will have Mr. Armstrong address that in a minute. To answer your question, the answer is, yes, we found that. We found that there was no system presently available that would have prevented this accident.

Furthermore, we took considerable testimony from astronauts and others about whether it was possible to devise an abort system that would be workable during the time of the first 2 minutes while the boosters were on. I think that the general conclusion was no.

There are some people who think it would be possible to do that, but most of the astronaut community feel that attempting to restructure the orbiter to provide for an abort capability in itself and anything else they might do would be dangerous, that it might create accidents; therefore, we did not make that as a recommendation.

I know NASA is giving thought to all aspects of it. Dr. Ride, who was in charge of that panel, conducted some investigations about it. Our recommendation is based largely on the work of her panel. I think there is additional testimony that she took which would be available to the committee on how others feel about that.

We took some testimony from the astronauts in public session about it, and I think the general feeling was that it probably was not feasible. There was a feeling that more attention should be given to the abort possibilities in a gliding mode. I think most of the astronauts feel there would probably be no survivors from a water impact. I guess with an abort mode there is some possibility of separating the glider in a way that would make it possible for some other landing, but that is all being studied by NASA, as we think it should be. Neil can expand, I am sure, on this.

Mr. ARMSTRONG. Mr. Chairman, a number of studies have been done by NASA since the inception of the shuttle design, including

various possible escape and abort modes. They always concluded that it was not practical to include such a system in the design.

Our limited review of those considerations led us to believe their conclusions were probably correct. However, we were quite convinced that two things could be done: One would be to provide the escape possibility which you quoted to allow survivors in the case of a ditching; and second, to improve the situation with which a return to launch site abort would be possible with a failure of more than one engine.

Senator GORTON. I presume when you speak to that, you speak of that failure which would be after the first 2 minutes after the solid rocket boosters have exhausted?

Mr. ARMSTRONG. Yes, sir.

Senator GORTON. Go ahead.

Mr. ARMSTRONG. We had supported those to the extent we included them in the recommendations.

Senator RIEGLE. Mr. Chairman, would you yield very briefly before moving off that point?

Senator GORTON. Go ahead.

Senator RIEGLE. I will be very brief. You raised this, and I think very importantly. The conclusion I draw from what I am hearing is that because there is not a way to design in an escape mechanism during that first 2 minutes of launch, that that ought to lead us to the conclusion that we ought to take every conceivable problem that we know of that occurs during the first 2 minutes and see that it is fixed; in other words, that is the time when we have no backup safety measure, in a sense.

So the conclusion I draw is that we have to, within the bounds of the human mind, make sure that every conceivable problem that can arise in that 2 minutes which we can anticipate and head off, we do so that it does lead to a conclusion about a safety premium that has to be built in during the first 2 minutes of launch.

I thank you for yielding.

Mr. ROGERS. Mr. Chairman, if I could say, at page 211 we cite the panel and what they considered. You will see that on two occasions, April 14 and 15, there were hearings on the abort possibilities. If your staff is interested, we can very quickly give you that information when you want it.

Senator GORTON. That would be a great help. I did want to go on to the related point of the return to launch site. Obviously, you feel the capability of dealing with that kind of emergency could be enhanced. What does that imply about the extent to which an emergency landing is possible, given current shuttle configuration?

I think, Mr. Armstrong, that might be for you.

Mr. ARMSTRONG. The limitation for this case currently is software development limitation. It is our understanding that with additional program improvements, the shuttle would be able to expand the envelope from which it could conduct a safe return to launch site abort. That seems a reasonable goal to pursue at this point in time.

Senator GORTON. I will have time for only one more question, and then we will go back to the solid rocket booster joint performance.

You were able, of course, to marvelously come up with, beyond the shadow of a doubt, the physical cause of this failure—a faulty seal design—with possible contributing conditions from joint temperature, putty performance, ice in the joint, assembly anamolies, to name a few.

Were you able to isolate any further than that the cause for this accident, as Admiral Truly told you, something that happened in this connection as long ago as STS–2? Are you able to say with any confidence, even with over a 50–50 chance of being correct, for example, that had it not been for the abnormally low temperature, there would have been no accident? For example, had no launch gone off at less than 50 °F, is there a probability that, in spite of the rest of these design failures, that we would not have had this catastrophe?

Mr. ROGERS. Well, it is a little difficult, as you have indicated, to be sure about that. My own view is that probably the weather was a major contributor to this accident. It also is possible because the design was a faulty design to begin with and because they had had trouble with it before. It is quite possible you could have had an accident at temperatures of 55, and there is no way to conclude that. All you can say is that the worst experience they had was in colder weather, and this day was colder than the worst case before.

Second, this right booster rocket was colder than the left, and the spot on the right booster that failed appeared from our test and the testimony we received to be the coldest spot on that booster.

So, in putting together those facts you can draw a conclusion that the probability is that environmental considerations may have made a difference. Can I or anyone say conclusively that it would not have happened if the weather had been warmer? I do not think you can say conclusively, but in answer to your question my own view is the probability is that if the weather had been warmer this accident might not have happened.

Senator GORTON. Thank you. By my own rules I have run out of time, and I will turn it over to Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Mr. Secretary, at the beginning of the space program there was an extraordinary degree of national urgency and consensus and, really, there was a degree of excitement in putting a man on the Moon, that particular man. It would really galvanize the Nation and created a sense of urgency. From that, it created a special NASA, focused and concentrated with every instinct for the high accuracy, laser intensity, high morale, correctness of decisionmaking.

Then, as so often happens, and I have seen, with so many new agencies things begin to—Neil was put on the Moon. Times passed. The launches go up. People relax just a bit. Funding seems to be secure. Then it potentially turns into bureaucracy as you have essentially said that in your report. Then there are cozy relationships; the question of pressures, pressures to militarize, pressures of budget, pressures of new competition with the Europeans and Ariane, with the Chinese, and the Japanese, the pressures of decreasing budgets from the Congress, the pressures to put politicians and teachers and others into space; all kinds of pressures.

Now, my question is with all of this in mind and with the prospect that just perhaps throughout this process in the recent years we have lost focus of the real goals of the space policy, do you think based on your observation, that we can rebuild the program. And can we do it under the existing budget constraints and yet control these pressures so that NASA, not yet clearly with a mission—right now they are in retreat, and right now they are regrouping, and right now there is argument whether they should launch in 1987 or launch in 1988—can get back on track.

What worries me is all of a sudden we are talking about timetables again. Maybe there is the need to talk about the real goals, what we truly need to accomplish, prioritize as Nos. 1, 2, 3, and 4.

Now, is it your sense, having worked with these people, that we can do that? That the Congress working with NASA under Jim Fletcher and implementing a variety or all of the suggestions that you have put into place, do you think that NASA is going to be equipped to withstand the pressures so that they can concentrate on real missions and stay away from really backtracking to launch schedules and the minutia of schedule, which I think has caused some of our problems?

Mr. ROGERS. I will let Neil answer that in a moment.

My own view is that yes, we can do that. I think that the Nation has the ability to do almost anything that we set out to do if we have the will and we have the support of the American Congress.

Now, it is not going to be easy. There is no doubt about that. It is not going to be easy, but I think in getting to know a lot of NASA people that they have great talent there. I think that there is a challenge. You have the Space Station coming along, and you have a lot of competition from other nations.

I think the American drive is such that we can do it. I think that we, as a people, have not only the technical expertise, but we have the human initiative and drive that is necessary. If we decide to do it, it is not going to be easy. That is one of the problems Congress is going to have to face, and one of the problems the President has to face, and one of the problems the American people have to face.

To answer your question, I was in the Eisenhower administration, and I never thought we would get a man on the Moon. I never thought it would be possible to have a man on the Moon and that I would be sitting next to him.

Mr. ARMSTRONG. I did not think so, either.

Mr. ROGERS. So I guess the answer is yes. I think we can do it. It is not going to be easy.

Senator ROCKEFELLER. Thank you, Mr. Secretary.

One other question for the moment. You have this problem of sole-source contracting. Now, you speak forcefully and properly, in my judgment, of accountability. We have decided not to assign individual responsibility, but we know that there were decision flaws with respect to NASA and Morton Thiokol and others, so you come down heavily on accountability.

Part of accountability is quality control, competitive bids and the rest of it. Now, if you are going to build a Trident submarine you have got to go to Electric Boat, because they are the only folks that build it. I do not criticize that, but now we are talking about a dif-

ferent kind of program. You have highly specialized NASA component requirements, instruments.

Two hundred and fifty House Members want to reopen competition for the solid rocket boosters. Now, I am not going to pass judgment on that, but it is a question of sole-source bidding. It is something that we do not control in this country in the private system, who goes into what kind of business, who decides to make what kind of product.

Does the problem of sole-source bidding weigh on your mind?

Mr. ROGERS. Yes, I think it is a very real problem, and it is one that the Administrator of NASA is going to have to deal with. It is one that Congress has to deal with. I was personally disturbed about the comment that the head of Morton Thiokol made as reported in the Wall Street Journal, to the effect that, after all, he was not too concerned because they were the sole supplier.

I think that was after I made some comments about how Mr. Boisjoly and Mr. McDonald had been treated, and I thought that was a very unfortunate comment. It is a matter, I think, of concern. I hope Morton Thiokol, if it continues to be the supplier, does not have that attitude.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Senator GORTON. Senator Danforth.

The CHAIRMAN. Mr. Secretary, I would like to ask one general question, and that is what lessons have we learned, if we have learned any, about a relationship between NASA and its principal contractors.

The impression I have is that this was a case of a contractor being very dependent on NASA, and NASA being very dependent on the contractor as its sole source for a major portion of its operation; engineers of the contractor recognizing the danger of the launch; management in the process of negotiating a new contract.

I think that is correct. Is that right?

Mr. ROGERS. Yes.

The CHAIRMAN. It appears that management at Morton Thiokol was in the process of negotiating a new contract with NASA, and overruled the engineers and that subsequent to the accident, the engineers who had opposed the launch were transferred elsewhere. Finally, they were recalled after this came to light. It appeared to me to be a major question that has not been addressed, at least by us, in the last few months, as to, one, what was the behavior of Morton Thiokol both before and after the accident; and second, and I think, more significant, from our purposes, what lessons have we learned about the relationship between NASA and its principal contractors?

Mr. ROGERS. Let me get started in my thought process. First, I think we learned that the contractor is going to have to stand up and be counted, whatever his recommendation is. It is a matter of record.

In the case of Rockwell, they appeared to or they thought they recommended against the launch because of the weather conditions. The NASA people said they did not understand that. They did not understand that there was a no vote.

So it is clear that the contractors, if they are going to be partly responsible for launch decisions, have to be on the record. They have to say yes or not, and it has to be clearly understood.

The same thing is true in the case of Morton Thiokol. I think there is an impression that only the engineers voted against the launch. That is incorrect. The whole company voted against the launch, engineers and managers. There was a written recommendation that there should be no launch unless the temperature was 53 degrees or above.

What happened subsequent is that at the urging—and maybe that is too strong a word—at the suggestion of NASA people saying that they were appalled by that recommendation and that if that recommendation stood they would not be able to get the launches off until April, at that point the Morton Thiokol people went off the line and had a private conversation and changed their minds. This is all a matter of record.

Now, they did not change the minds of the engineers. They changed the mind of the chief engineer, but they told him to take off his engineer's hat and put on his manager's hat. Then he voted the other way. He voted to launch. So the three managers and Mr. Lund changed their mind and voted to go ahead with the launch. The engineers did not change their mind. In fact, the engineer at Kennedy strongly opposed it and would not sign the telefax which NASA insisted on receiving before they would go ahead with the launch.

So we say in our recommendation that Thiokol changed its mind. They did it to accommodate the customer, a major customer. That is our judgment, and I think that is a fact. That suggests that the relationship was such that NASA was able to influence their judgment on such a critical matter. That is something I think Congress is going to have to consider, how those things will work out.

In any event, there should be a clearer record of how everybody stands. If the engineers who built this joint and who were most qualified to deal with it still said do not launch, that very fact should be known to everybody who made that decision. In this case, the people who made the decision to launch said we knew nothing about that.

If you look at our report, you will see how many people were involved in that discussion and how long the discussion took place. They had never had a discussion of this kind on the eve of launch that lasted so long with so many people knowing about it. How it happened that the key people knew nothing of it is hard to understand, but I believe them when they said they did not.

So, yes, I think the relationship between the contractor and NASA becomes very important. We have no recommendation to make. I do not think that was in our charge, but it certainly is a matter that Congress will have to consider.

The CHAIRMAN. Do you have any thoughts for us, for example, about the advisability of sole sourcing with a single contractor or concerns about the degree of dependence of an agency or—a single contractor?

Mr. ROGERS. Well, if we are going to—and here again I am speaking now personally because we, the Commission, did not consider this—I would think if it is possible from budgetary matters to have

a second source of supply, it is very desirable. Certainly if we are going to be in the position where, in the years to come, we have a very active program with a lot of launches, reliance on any one source, it seems to me, is very questionable.

The CHAIRMAN. Thank you.

Senator GORTON. Senator Hollings?

Senator HOLLINGS. Well, now, Mr. Secretary, on that score, you do find, as I understand, on page 104, that they overruled the recommendation against launch in order to accommodate the customer. I think we ought to look just at that one point for the limited time that I have, and then we can get to some of the other concerns I would like to raise.

Is it not a fact that Mr. Lund, who was a vice president in charge of engineering, was the man who went in August 1985 to brief NASA on the O-ring problem. So he knew all about the O-rings, and he was saying that it was a Criticality 1, that its failure would result in the loss of crew and mission. And thereupon, as you indicated—I think it is on page 90—he had a written recommendation against the January 28th launch of the shuttle *Challenger*. This is a little handwritten memo that he had telefaxed to NASA

Now, on page 139, Mr. Boisjoly, among other valuable information he has provided, brings in a very important fact that I found early on. Earlier in discussions I had with Allan McDonald, who talked to me on the telephone, I discovered he had been at the Marshall Space Center on the Wednesday and Thursday before the launch to discuss renewal of the solid rocket booster contract. Morton Thiokol was very concerned about that contract because as Mr. Boisjoly said on page 139, they were sensitive to losing that particular contract to a competitor if a timely solution were not found.

And it is quite obvious from my review, and I suspect NASA was using the threat of a second source to pressure Thiokol to get a lower price. The Congress in last year's authorization bill said, look at second sourcing. So there was economic pressure on Morton Thiokol. And is it not the truth that when he said, let us take off that engineering hat and put on that management hat, in reality what he was saying is, let us take off that safety hat and put on our pocketbook hat?

They were not accommodating the customer; they were accommodating Morton Thiokol's pocketbook. That is what they were looking at. That is the kind of contractor I saw. That is why I was concerned, like you, when they demoted Boisjoly and McDonald for talking too much. It was, as they said, Chairman Rogers, forget about him; we are the sole contractor. We do not have to worry about him.

That kind of thing puts me to giving the Good Government Award to the engineers of Morton Thiokol but a kick in the you-know-what to the management out there. I do not think they are competent managers to take on the arrogance of that particular attitude. I do not find, as you do, on page 104, that it was to accommodate the customer. I think it was to accommodate the Morton Thiokol pocketbook.

Mr. ROGERS. I agree with you. I think it means pretty much the same thing. You accommodate the customer, you help your pocketbook.

Senator HOLLINGS. Well, that is what they were looking at. They were really concerned about that second-sourcing, and they had Allan McDonald down there 2 days before trying to negotiate it and everything else, and when they got into this discussion that we all have—the Commissioners provided us the record for it—when he says, take off your hat and put on the management hat, you and I have been in business and management, too, as well as politics. You know what that means.

Let us get to the pocketbook. Let us not talk about safety anymore. We have got a contractor and we are threatened with a second source here, and let us forget about safety and think about our pocketbook.

Mr. ROGERS. I agree.

Senator HOLLINGS. Well, let me emphasize one thing. I was not differing with respect to the safety, recommending a person in charge of safety. I do not differ with that, but that is not necessarily my view. I thought they had certain safety procedures. They had, for example—and I do not know whether I will get the time in here—the criticality 1 that Mr. Mulloy treated as criticality IR. He overruled that criticality 1. He changed the criteria.

And I do not see that he did conform with the particular procedure in order to change that criteria. What we had was a Criticality 1 item being treated as IR. Is that not correct, Mr. Secretary?

Mr. ROGERS. Yes, that is right.

Senator HOLLINGS. And the manual said that they could not change that without notifying level I and level II, so now he is changing that criticality 1 and changing that without notifying those. And then, when he is reminded that he is doing it, by Allan McDonald, he is giving this, what do you mean? Next April? Are we going to have to wait until that time in order to launch?

I find that gross negligence. I do not think he was trying to kill astronauts. Let us be blunt about it. But I think his conduct was of the type and nature, willful, gross misconduct, when he overrules a Criticality I item of that kind and the safety procedures that are inherent.

Our friend, Jesse Moore, said they never launched over the objection of a contractor. Here they were launching over the objection. That could not be taken lightly. The entire procedure, according to Allan McDonald, was for the NASA agency to pressure and cross-examine the contractor of launch. And here as Bob Crippen has said, it was totally reversed.

And one of the main culprits is the gentleman, Lucas, out there. I watched him testify with you, and then he went back and had a news conference and he said we would do the same thing over again. There was no remorse. There was no misgiving. There was no understanding of individual responsibility, and if there is one fault so far—and I am going to be fair with you, I have not been through the entire report and I am trying to get through all of the particular parts—but that tendency not to fix individual responsibility is what bothers me.

I think if you fix that, if you fix some of the Lucases and you fix some of those who had a total disregard, some of the Mulloys, and you fix those folks up at Morton Thiokol who said forget about safety, let us get into the pocketbook, the program would be better off.

Would you comment on that, please?

Mr. ROGERS. Well, I agree with generally what you have said. I think our report does reflect that, and we have asked that the system be changed so that the responsibility is fixed and people know exactly who is responsible for certain things.

For example, on the constraint that was placed on these flights, there were five previous flights prior to 51-L had a constraint on them, which means that there was something wrong with the joint and that it should be fixed.

Senator HOLLINGS. And it had been waived. They had waived them on five previous flights?

Mr. ROGERS. That is right. And I think that is what you have in mind about the constraint. It was a criticality change. I do not think Mr. Mulloy changed the criticality matter, although the criticality was changed. Originally it was criticality 1R, which means that there was a redundancy in the seal, there was a backup seal which would protect in the event that one seal failed, and that was changed in 1982, as I remember.

And I do not think Mr. Mulloy had anything to do with that, but he did have something to do with the constraint, and he placed constraints on five previous flights. And then he removed the constraints by himself. And we recommend that that system be changed, that if there is a constraint on the flight then it should not be removed unless the problem was solved or that there was adequate discussion and consideration about removing the constraints.

What happened here was Mr. Mulloy put on the constraints and then removed them. It was meaningless. You had what was a constraint that had no meaning. Nothing was done to fix it.

Senator HOLLINGS. But he did not notify levels I and II.

Mr. ROGERS. That is correct.

Senator HOLLINGS. He did not tell Johnson and he did not tell Washington headquarters, and that is really where the safety or process was violated. He should have, should he not?

Mr. ROGERS. Well, he said he should not, but we think he should have; yes.

Senator HOLLINGS. Well, does not NASA think that he should have?

Mr. ROGERS. I think so. But it was not any one thing. There were several failures of the system, and I do not mind your words. The words you chose are fine with me.

Let me say the reason we used the word "flaw," "possible flaws in the system," is because I wanted to explain publicly why we asked some of these people involved in the decisionmaking to disqualify themselves from being involved in the investigation. So we had to use some word at that point. We were not exactly sure what happened, but we said we thought the process might be flawed, and we were able, as a result of that, to disqualify the people who were involved in that decision from being a part of the investigation.

So I do not take issue with you on the words you used at all. Obviously it was a failure in the system. It was a flaw, if you will. It did not work, however you state it. The facts are all there, and I think any full reading of the report will cause anybody to have a feeling of sadness that it happened. You say I cannot imagine how it happened, but there it is. Those are facts that were all there that can be looked at. I think they are accurate facts, and it is hard to explain them all.

I do not think there is any one explanation. I think it is a sad story of a failure and we have tried to set it out as completely as we can.

Senator HOLLINGS. But why not the individual responsibility, Mr. Secretary? You know what bothered me about Mulloy when he first appeared before you when he started reading that important answer that some lawyer had written out for him? I have been in a courtroom as have you. And I knew he knew all about the program. Then, all of a sudden he was reading his answer to you. That bothered me.

I said that fellow—unfortunately, what McDonald said was true.

Mr. ROGERS. Well, I guess on assessing blame I am just expressing my own view. I can understand how people feel differently. I have reservation from a standpoint of a prosecutor whether you would ever have a successful prosecution of anybody. You might be able to proceed, but I doubt it. I doubt that there is enough willfulness there.

Second, I doubt that it would serve the national interest. I do not see what is to be gained by it. I mean, everybody is on notice. The people involved have suffered a lot and I think that it is the fault of a system. It is a failed system and I am not sure picking out any scapegoat and prosecuting him would serve the national interest. I hope it does not happen. I just hope we can get on and get back into space.

Senator HOLLINGS. I am just trying to fix responsibility. I am not trying to prosecute. But I just do not want to sit it aside and say you can retire so long as you keep your mouth shut. I have got some questions later on about pressure.

Mr. ROGERS. Well, I understand. I think the NASA people, I think Jim Fletcher and others are moving to make changes. I think the changes they have made have been pretty good so far and I think we have to leave it up to them. I certainly am not in a position—none of us are on the Commission are in a position to recommend to him how he staffs his operation. I think he will do a good job.

Senator GORTON. Senator Riegle?

Senator RIEGLE. Thank you, Mr. Chairman.

I want to follow along the lines of Senator Hollings 'question, but before I do I want to say what I have said in other settings, and that is to congratulate the Commission, you, Chairman Rogers, and Mr. Armstrong, and your counsel for, I think, an extraordinary piece of work and a great public service under difficult conditions. We are very much in your debt.

I have some concerns, too, about the rest of this story in terms of tracking down anything that requires fixing in a specific way. Now, Mr. Mulloy, for example, is still working for NASA, is he not?

Mr. ROGERS. Yes; I think so.

Senator RIEGLE. Do you know what capacity he is working in?

Mr. ROGERS. I do not. It has been reported in the paper that he has. I do not know. I guess it is. Dr. Keel says he thinks he is an assistant to Mr. Kingsbury, but I am not sure.

Senator RIEGLE. The thing that you mentioned, the terrible sadness of this tragedy, and it is that. I mean, words fall short in expressing how sad it is. The only thing that would be sadder, in my view, is if we had another accident in the future with any of the same problems cropping up—either individuals or procedures—and I feel very strongly that if we fix the mechanical problems and we do not fix the people problems we have not done our work.

I understand the delicacy in the job the Commission is trying to do here of essentially shining the light where it needs to be shown without necessarily pinpointing individuals. But I think I tend to feel, as Senator Hollings does, that I just want to make sure that the individuals who behaved improperly, did not follow procedures, were involved in a fatal decision to seven other individuals, are not allowed to participate in these decisions in the future. I feel very strongly about it.

And, as we sit here today, we have no assurance in that area other than it gets very vague that presumably changes will be made and so forth. I think we need something a little stronger than that here in terms of an assurance that the people who behaved improperly and who did not do what they should have done will not be allowed to participate in any material way in decisions in NASA again. And I guess we do not have that assurance at the moment.

Mr. ROGERS. Well, I certainly do not take issue with that.

Senator RIEGLE. Pardon?

Mr. ROGERS. I do not take issue with that at all. I think you will find that the Administrator probably will support what you said. I can not speak for him, but I think he is well aware of that and I am sure you will ask him questions about it. I do not think that our Commission felt that we should do that, make that decision ourselves.

But, as you can see, we have not made any recommendations about changes of personnel, and already a lot of them have been made, and I think others will be made. I think that is what the new Administrator has to do. I do not think we should do it. I do not want you to think that we are reluctant that it be done. I am just saying that I do not think that it is our job to do it.

Senator RIEGLE. Let me ask you a related question. On page 148 of the report you note, under item 5, you say the O-ring erosion history presented to level I at NASA Headquarters in August of 1985 was sufficiently detailed to require corrective action prior to the next flight. Now level I would be the top level in NASA, would it not?

Mr. ROGERS. Yes.

Senator RIEGLE. And one of the things that has confounded me from the beginning is how people at the lower levels could engage in a flawed pattern of activity and decisions for a long period of time. We had a serious problem. It was not fixed. But yet it has

taxed my imagination to think that at no time did that ever work its way up higher into the NASA hierarchy.

If that is the case, then there is something wrong in the communication system, and you in a sense say that in another part of the report. Who would have been present at that session, the level I meeting at NASA headquarters in August of 1985 when the O-ring problem, as you say, was sufficiently detailed to require corrective action?

Mr. ROGERS. I will ask Dr. Keel to answer that.

Dr. KEEL. The highest level, Senator, that was there from level I was Michael Weeks, who is a deputy associate administrator for space flight.

Senator RIEGLE. So he was the sole person representing level I?

Dr. KEEL. No. He was the highest level person.

Senator RIEGLE. Are there any other people from that level whose names you recall who were at that meeting?

Dr. KEEL. Well, some of Weeks' assistants working in the level I office were there.

Senator RIEGLE. Were there also people from level II at that session, or did they jump a level? It was III talking to I here?

Dr. KEEL. It was III talking to I.

Mr. ROGERS. As a matter of fact, on that point level II has been sort of cut out of this loop, and that is one of the things Mr. Aldrich complained about. You will see some of his testimony. He did not understand why he was cut out and he was sort of cut out of the budgetary process, too, on some of these things.

Senator RIEGLE. Did the level I officials who were at that meeting, did they do what they were supposed to do and, if so, why weren't these problems flagged and fixed?

Mr. ROGERS. Well, here again we cannot answer that. They obviously did not, and their testimony was they did not realize the seriousness of it.

Senator RIEGLE. But I guess you drew a different conclusion, because you feel here that what was presented was sufficiently detailed—and these are the words of the Commission—"sufficiently detailed to require corrective action prior to the next flight." I guess that is the unanimous conclusion of your group?

Mr. ROGERS. That is right.

Senator RIEGLE. Well, was the level I official present asked pointedly as to why he then did not take what was a compelling presentation and do with it what should properly have been done?

Mr. ROGERS. Yes. And that is all available to the committee.

Senator RIEGLE. Well, were there satisfactory responses or was there failure to perform on that individual's part?

Mr. ROGERS. There were not satisfactory performances.

Senator RIEGLE. Well, presumably my same concern then has to be stated again, and that is that anybody in a significant management position that really did not do what they should properly have done, I think ought to be taken out of the future management decisions. And I would apply that just as readily to level I as I would to the people that we have talked about in greater detail at level III.

Do you have any response to that?

Mr. ROGERS. Well, I do not disagree with you. That is all.

Senator RIEGLE. I want to make sure that and whatever other supplementary materials that you have developed and communicated to Dr. Fletcher, that we have got a clear identification of the points at which there was a specific breakdown, a specific management failure by an individual, and that is simply to make sure that in the future, when we have got the mechanical problems fixed, we have also got the management problems fixed in each key assignment.

Mr. ROGERS. Well, that is right, and we will be happy to do that, Senator.

Senator RIEGLE. Now, with respect to the Morton Thiokol issue—and I think Senator Hollings makes a very important point about the fact that they were negotiating a renewal of their rocket contract at virtually the same moment that the *Challenger* launch was being prepared, and in fact, if I understand it right, there were meetings the week before the *Challenger* launch on the question of the contract renewal. And then there was a meeting scheduled, as I understand it, the very day of the launch later in the afternoon, where Morton Thiokol individuals were going to sit down with NASA and perhaps even finalize or come very close to finalizing the rocket contract.

Are you aware of that? Is that generally within the knowledge of the Commission?

Mr. ROGERS. I am just not sure of the time sequence. It is about right. Of course, at that time the renegotiation of it was not all that significant in the sense that there was no other source of supply. But there was testimony, I think, from Mr. Boisjoly, a document, as a matter of fact, in which he talked about the concern about developing a second source of supply. That really was a concern and that would lead one to think that maybe that is why they wanted to satisfy NASA in this decision.

Senator RIEGLE. Well, it certainly appears that way. It appears that, as you say, they did not want a second source of supply and so they were clearly in a frame of mind to want to be as accommodating to their customer, NASA, as they could be, particularly at the time when they were going to sit down and renew these contracts. That timing, I think, is very, very troubling and disturbing in terms of the pattern that we see on either side of that time in which the launch took place.

Are you satisfied in your mind that no one above the level of level III was aware of the serious objections to launch either by Morton Thiokol or by Rockwell prior to the time the launch was made?

Mr. ROGERS. Well, you have to divide the question in two parts. In Rockwell's case, of course, they made their opposition known to level II, and I think it probably was known to level I. As it turned out, that aspect of it did not contribute to the accident. In other words, their concern was the condition of the launch pad and ice on the launch pad.

Senator RIEGLE. But might it not have—I mean, the fact that it did not in a sense relate to this accident, the fact that there was a safety concern that might have threatened the launch in the opinion of the subcontractor to the point that they were saying that there were great dangers in the fact that we fired it off, and that is

not what caused the accident. Should we really take any great measure of security out of that fact?

Mr. ROGERS. No, no, not at all, and we say so in the report. We point that out. As a matter of completeness and as a matter of fact, it is pretty clear that that ice on the launch pad did not contribute to this accident. I agree with you fully that, and we say so, that when a contractor expresses that concern that should have been paid more attention to.

Senator RIEGLE. And what NASA managers at the level I or level II position were aware of that concern prior to the launch?

Mr. ROGERS. Well, that is in the report. I think the head of level II knew about it, Mr. Aldrich, and that is in the report. I think that was generally known, that there was. I do not remember who else knew about it, but that part of it was not closely held. I mean, there was a lot of concern about the ice on the launch pad, and Rockwell, being the contractor, was there at the time and their people expressed concern about it. So that part of it was known.

Senator RIEGLE. Was the single individual responsible for the final go-ahead for the launch informed of that information, to your knowledge?

Mr. ROGERS. I think so. That is my recollection.

Mr. ARMSTRONG. That would have been Mr. Aldrich.

Senator RIEGLE. So Mr. Aldrich was the person responsible for the final decision. Insofar as you know, he was aware of the Rockwell reservations but not the Morton Thiokol reservations?

Mr. ROGERS. Oh, sure. We have got a lot of testimony on that.

Senator RIEGLE. That is my assumption, but I just wanted to have in clear in the sequence of these questions that that was correct.

Mr. ROGERS. I do not remember for sure whether Jesse Moore knew about it or not.

Dr. KEEL. Mr. Aldrich chaired the mission management team meeting where the discussion took place at 9 a.m. in the morning, and then he went in and informed Mr. Moore, who was level I then, of that concern.

Senator RIEGLE. Of the Rockwell concern?

Mr. ROGERS. The answer to your question is both level I and level II knew about that concern.

Mr. ARMSTRONG. I might just add, Senator Riegle, that as you know this concern was for icicles falling off the launch facility, and being deflected one way or another into the thermal protection system of the orbiter, which Rockwell is very sensitive on, and damage to that thermal protection system.

In the investigation by the Commission, although you will find that we discussed this in some length, the Commission did not determine that that information was not passed along, nor that Rockwell concerns were not adequately expressed. As a matter of fact, a fairly careful examination and analysis was done of the trajectories the icicles might take on their way to possible impact on the thermal protection system, and as a matter of fact in general that analysis, as far as we know, was reasonably correct.

Nevertheless, the Commission was concerned that this level of concern when forwarded by a contractor perhaps should have been evaluated in a different or more thorough way.

Senator RIEGLE. Thank you. My time is up.

Senator GORTON. Senator Gore.

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

To begin with, I would like to follow up on one loose end, based on Senator Riegle's questions. Dr. Keel, you referred to the number of people or the specific people who were in that decisionmaking loop, signing off on the O-ring problem and other criticality 1 issues.

Is it not a fact that beginning 2 years ago the chief engineer was removed from the group assessing those particular issues?

Dr. KEEL. That is correct. In fact, the chairman referred to that comment in our report here, that he did not know after 1982 roughly of the O-ring problems.

Senator GORE. Well, that is one of several indications in the report that there was a general deemphasis within NASA on quality control and reliability assurance. Would you agree with that?

Mr. ROGERS. Yes, we certainly do. There were a lot fewer people employed in it, and so forth, that is correct.

Senator GORE. In fact, you state explicitly that reductions in safety, reliability, and quality assurance work force at Marshall and NASA headquarters have seriously limited capabilities in those vital functions. And I would say that that same conclusion is implicit in your recommendation for a new safety organization.

Mr. ROGERS. That is correct.

Senator GORE. Now, in addition to the new safety organization, you are also recommending a safety shuttle panel. I am interested in how you would envision this panel interacting with the new safety office.

Mr. ROGERS. I will let Neil answer that, because he was very close to that recommendation.

Mr. ARMSTRONG. Senator Gore, these two functions are really quite different. First let me talk about the overall safety organization, which naturally NASA has had historically good safety organizations, and currently, particularly on the aeronautics side, we think they seem to be operating very effectively, and the quality of many of the people in the space side safety organization is very good.

But it is a matter of management emphasis, and we just found it a thunderous silence in the fact that we had gone through months of hearing and nobody had ever mentioned what the safety people had to say about anything. That seemed like a glaring omission to us.

So we thought this function should act like an outside auditor in a business, an independent function that has access to the very top and sort of like at the board of directors and can say, this work is being done adequately or not.

The safety panel, on the other hand, although we would visualize it as having representatives from a professional safety organization, would be more a working level organization at the program level. We were concerned by the fact that many witnesses who testified in front of the Commission expressed frustrations about safety issues that they did not think had been properly or adequately or fully handled over the course of years.

And it seemed important to us that people in the agency who had such concerns have a place where they can go, where such issues will be handled. And we suggested the safety panel, which would have representation not only from safety people but from operations people, from crew people, from flight directors, and from program offices, and R&D people, whoever, who were close to where the action was and knew where the problems might be, so that they would have sort of a court of appeals to go to.

Senator GORE. All right. That certainly explains it thoroughly.

Let me ask a related question, and this question may go slightly outside the boundaries of the mandate of the Commission. I hope you will be willing to answer it, because you have gained so much peripheral knowledge in your work.

Many outside experts on the space program have, in taking a longer view of what has happened at NASA, made the point that in the aftermath of the Apollo program the Agency seemed to lose its focus a little bit. And they have posed the hypothesis that in the absence of an inspiring and all-consuming goal of the kind which energized the space program during the Apollo years, that the loss of that focus caused the Agency to sort of drift.

Now, with regard to this last question I was just asking, in the Apollo years the position of chief safety officer attracted some of the best people in the country. And you know, they are vice presidents and heads of some of the major aerospace firms now.

And then afterward, there was a period of 2 years where the position was totally vacant. They could not find anyone to take it. They finally got someone on the condition that the person could remain in California, or at least that was part of the discussions.

And then of course, it has been filled since then. But there is difficulty in attracting the very best people and so forth, could that also be related to the absence of the kind of inspiring goal that existed during the Apollo program? Basically, to boil the question down to its essence, do you think there is something to this view, that the problem stemmed in part from the loss of focus and the failure of either the executive branch in a series of administrations or the Congress to set a new goal worthy of succeeding the goals of the Apollo program?

Mr. ROGERS. Well, I think I will have Neil answer that. But let me say that I think you put your finger on a major problem that we face: How to attract the very best people to this program. And it is going to be increasingly difficult.

We have had some talks with Jim Fletcher about it on how to attract the best young engineers and how to challenge them and so forth, and I think it is a very major problem and I think there is a lot to what you said. As I say, Neil knows a lot more about it, and he was involved in the Apollo program and he may have some answers for you.

Mr. ARMSTRONG. Well, I would look at it a bit, Senator, like the previous analogy I used, which was an audit department in a business. The businesses are often concerned that people who go into the auditing function might lose career track and not be able to go into the line organization, and they sit out there on the side and are dead-ended.

I think in a similar way organizations such as safety organizations might have the same kinds of concerns. I do not think it is necessarily true that it has to be that way. All one has to recognize from a management point of view is that quality people have the opportunity to go into the safety organization, provide that function for some years, and it not be a barricade to further progress, and have the ability to take what they have learned from that auditing function and go over into another line organization or another outside organization.

I think it need not be a barrier. I think it is just a challenge to management to properly organize it.

Senator GORE. Well, let me phrase the question a slightly different way, because what you are saying might not conflict with the hypothesis that I threw out at all. It might well be that, even though the career path in the safety organization has been looked on as a dead end in the past, that while we were trying to go to the Moon and while we had that inspiring goal, people were willing to serve in that part of the Agency in spite of the fact that it might be a dead end career path, in order to be part of this inspiring effort to reach the goal.

When the level of inspiration fell, the 110 performance level began to decline and any underlying weaknesses in the structure of the Agency, such as this dead end career path, just to cite one of many examples, those underlying weaknesses began to surface.

Now, that is just a hypothesis, but I wonder if it fits with what you have seen during your work.

Mr. ARMSTRONG. It does fit, and we have devoted a chapter of our report to this subject because we felt so sincerely about its importance. And I really do believe that no one could now look at the shuttle program and not realize the inherent importance of the safety function and what a valuable service it can provide.

Senator GORE. My time is running out. Just a couple of brief ones if I have time.

Have you given thought to which of your recommendations will require legislation and which are purely administrative in nature?

Mr. ROGERS. I think most of them are administrative in nature. Of course, there are going to be budgetary demands on the Congress, particularly in repairing the joint and in providing adequate spare parts and other aspects of it. There may be costs associated with fixing and improving the brakes and improving the tires and so forth.

But I do not think there will be many other requirements for legislatiion.

Senator GORE. Thank you.

Thank you, Mr. Chairman.

Senator GORTON. In the course of your report, you make the comment that project managers in various elements of the shuttle program felt more accountable to the management of their own center than they did to that of the entire shuttle program organization. And the obvious conclusion you drew from that is it was a flaw in the shuttle management structure.

Could you elaborate a little bit on that and on how, with this great geographic dispersion of NASA, we can assure a cure?

Mr. ROGERS. Well, here again I think maybe Mr. Armstrong is better able to handle it than I am. In the course of our investigation, and not only from the testimony but from a lot of other comments and observations that were made by others who knew a lot about it, it was pretty clear that there had developed a sort of feeling of closeness among the people at the centers, and that was particularly true about Marshall.

And some people felt that that was in part responsible for Marshall's what appeared to be holding this information or some of it among themselves and not passing it on. And I think there was quite a lot to that, that changes have to be made.

And that is why we recommended that the headquarters and the new administrator consider more centralization. Now, exactly how that is to be done, we did not attempt to spell that out. But it certainly is true, for example, in the safety feature of it. The safety officer who was here, the chief engineer, really did not have his hands on the problems.

And that was also true in other respects. Mr. Weeks is a good example, that Dr. Keel referred to. So there has to be a better melding of the responsibilities, and headquarters has to take on more of the centralized responsibilities.

Mr. ARMSTRONG. Mr. Chairman, as you know, NASA has for many years used a matrix management structure, in which not all the employees but most employees are responsible vertically to their center and perhaps horizontally to their program.

And I do not find fault with that as a system. I am sure you can find deans of business schools from around the country who have various views as to what the most effective way to pursue matrix management is.

The Commission was struck, however, that in a program of the magnitude of the shuttle endeavor certain additional focus needed to be included. And we should not have the situation, as was testified to us, whereas the program manager, who really is supposed to be responsible for the overall success of the endeavor, does not—not only does not have control over certain budgetary functions, but does not even have knowledge of them.

And we considered what specific recommendations we might make and concluded that we would not be specific, only identified this as a problem and encourage the program manager to have the appropriate lines of responsibility to conduct his work.

Senator GORTON. I would like to go to another subject with the two of you, the subject of both internal and external pressures. Secretary Rogers, yesterday in the course of your news conference when you were asked—I think perhaps it was in the context of individual responsibility—you said that there was enough responsibility to go around and that it went well outside of the NASA organization itself, to a previous administration decision to put almost all our eggs in the shuttle basket, to an administration and Congress which made relatively high demands and had high expectations of NASA, but was not willing to fund it adequately, perhaps to an insufficient degree of oversight here, and to the press. And we had some examples of the way in which NASA would be criticized when it did not meet its own rather unofficial schedules.

I suspect you may agree that an awful lot of the pressure to launch was internalized as well, just simply the feeling in an organization that had been successful that it could continue to put great demands on itself. And I suspect it is inevitable that 10 or 15 or 20 years from now what we are talking about here today will be forgotten. But maybe some of the same human characteristics are still going to be around then.

Would you and Mr. Armstrong, if you will, comment to me a little bit about those pressures, how they came about, and what you think we might learn from this terrible tragedy about our own expectations, wherever they come from?

Mr. ROGERS. Well, you know, we tend as Americans to become very pleased with success. And we tend to cheer a little bit too much about success, and our cheers lead us on to even greater euphoria.

And the result is that you impose pressures on yourself, and I'm speaking about NASA and I'm speaking about everybody else in the country. You impose these pressures on yourself, that you have to meet your own advertising. And you advertise success and you say it is great and you say we are going to have these many launches and so forth.

And then you find that you cannot quite do it. And what I was trying to say was, it is easy enough to place blame on this or that part of the Government or this person or that person, but in a sense we were all responsible for it. I mean, to the point where, when there was the delay the day before this launch, the media made some vicious attacks on—at least some of the media made vicious attacks on NASA, as if the fact that they had to delay a launch because of the hatch on a door was a major problem, and they were subject to scathing criticism.

And everybody had gotten to the point of believing that these launches could occur—what were they talking about, 24 a year. When you look back on it, that is pretty unrealistic on the part of everybody. There are very few people that said: That is baloney, you cannot have 24 launches a year, it is not going to work; think of what you have to do.

You have to put these segments together, and then you fire the rocket and you land in the ocean, and you pick them up and put them back on the train, take them out to Utah, clean them up, put propellant back in, stack them on the train again, send them back to Kennedy, stack them, and be sure that they are stacked properly, and fire them again, and they are out in the ocean.

And that would require you do that 24 times a year. That is terrible pressure. You have got four orbiters, and you have to decide, well, if one orbiter is getting ready to fly and a part goes wrong, you have to cannibalize. You have to take the part off another shuttle and put it in. That's a dangerous operation.

So all those are pressures that we put on ourselves. I mean, it was not anybody. It was not Congress and it was not NASA, it was not the administration. It was everybody. We all fell into the thought process that this was going to work and we did not have to worry about it, and it was going to work fine and we were going to have a shuttle like the shuttle back and forth from New York,

where everybody gets on the shuttle. And everybody was volunteering, let's go on the shuttle.

Well, that is a psychology that prevailed, and I think that it does not prevail anymore. And I think that has been beneficial and it is all there. We can see what happened. All the facts are there.

And I think the real problem is, how are we going to deal with it in the future? And fortunately, we are going to leave, and we will leave this in your hands. That is the benefit of a Commission that only operates 120 days.

Senator GORTON. Mr. Armstrong, do you want to make a comment on that?

Mr. ARMSTRONG. I would only add, Mr. Chairman, I agree with your assessment that predominantly the pressure was internally generated, and it was generated perhaps because of overexpectation or acceptance of unreasonable commitments, level of commitments for the resources that they had available.

Senator GORTON. Senator Hollings.

Senator HOLLINGS. Well, let us talk about that pressure then for a minute. And let me ask, Mr. Secretary, before I get onto the pressure, with respect to the explosion, the tragedy. Immediately thereafter, if you remember, National Public Radio had been called by some of the engineers and their wives who said, our husbands cannot go to sleep, we want to make a statement. We do not want to necessarily go public at this time, but if we can just tell what happened to somebody of a responsible nature or a responsible journalist.

And so they went out and the statement was made, which I have a transcript of, where they said at 8:45—and I am just starting right in on part of the story—Thiokol General Manager Mason takes NASA officials off hold. That is the evening before, and he tells them: "OK, we will approve the launch after all." That is in quotes. And then: "They signed a document right away, and NASA's Mulloy tells them, send it to us by telefax."

Although one top Thiokol manager, Allan McDonald, who has been taking part in the conference calls from the Cape, refuses to sign the paper, the meeting breaks up. The engineers go home feeling downtrodden, defeated, and terribly worried.

"I kept having fantasies that night," says one engineer, "that at the moment of ignition the shuttle would blow up instantly. See, we thought that if the seals failed the shuttle would never get off the pad. There would just be a big fireball and everything would vanish. I was so scared I did not even want to watch the launch."

At the next morning, the engineer joins 50 other colleagues back at company headquarters in the same conference room where they had argued the night before. They were all watching the countdown together on the large projection TV.

When the shuttle lifted off the pad, he says: "I thought, gee, it's going all right, it is a piece of cake. And when we were 1 minute into the launch, a friend turned to me and he said: 'Oh God, we made it, we made it.' Then a few seconds later the engineer says: 'The shuttle blew up, and we all knew exactly what happened.' "

Did the Commission find out who made that statement, who that interview is with? Dr. Keel, do you know?

Dr. KEEL. Yes; we did, Senator.

Senator HOLLINGS. Who is that?

Dr. KEEL. That is Mr. Eberling and Mr. Thompson.

Senator HOLLINGS. The two engineers are Mr. Eberling and Mr. Thompson.

Dr. KEEL. Very good.

Senator HOLLINGS. Very good.

Now, with respect to the——

Dr. KEEL. I cannot certify that is exactly accurate in that press account, but——

Senator HOLLINGS. That is just a transcript of the statement made. I understand.

Now, with respect to the pressure that Senator Gorton asked about, you must understand the interest of this Senator, some of the others, and some of the public, because the Commission's report refers to the outside pressure and what involvement, if any, or interest did the White House have.

Now, we start of course with the President's program, announced in August 1984, of the first private citizen to fly in space. And it was quite a big ceremony, and we were recognizing the public secondary schools. And on November 8, after the election in 1984, then NASA itself released the announcement of the opportunity for the Teacher in Space Program.

Some 10,000 applied, 10,000 teachers all over the country. In May, the Council of State School Officers announced 114 had been chosen as nominees for the Teacher in Space Program. And then on July 1985, the 10 finalists for the NASA Teacher in Space Program were announced and they all went down to the Johnson Space Center for their medicals and initial space flight training.

And then on July 19, in the White House, they had a ceremony with Vice President George Bush announcing the selection of Christa McAuliffe, and millions of schoolchildren were turned on to this particular launch. And this particular Senator helped schools hook up with the satellite and everything else, so that all the kids were prepared when Christa McAuliffe was going up to conduct her classroom from space.

There was no question that NASA was not only complimented, but absolutely interested and enthused about it. And Dr. Graham and Dr. Culbertson submitted the final, draft input for the State of the Union Message that reads as follows:

> Tonight while I am speaking to you, a young elementary school teacher from Concord, New Hampshire, is taking us all on the ultimate field trip, as she orbits the earth as the first citizen-passenger on the space shuttle.

This text was submitted by NASA. Dr. Graham and Phil Culbertson that I know of checked off on this particular submission and asked that the President include it in his State of the Union message.

Quoting further:

> Christa McAuliffe's journey is a prelude to the journeys of other Americans and our friends around the world who will be living and working together in a permanently manned space station in the mid-1990's, bringing a rich return of scientific, technical, and economic benefits to mankind.
>
> Mrs. McAuliffe's week in space is just one of the achievements in space which we have planned for the coming year. The United States Voyager spacecraft has just this week visited the planet Uranus and sent back striking images of this distant world, after a two billion mile trip in space. Later we will participate in a worldwide

study of Halley's comet, launch the Hubble space telescope, launch the Galileo spaceship on its way to Jupiter, and participate with our European partners in sending the Ulysses spacecraft to explore the poles of the sun.

Our commitment to continuation of a strong civil space program through such projects as the space station, the space transportation, and space science and the technology required for the program of the 1990's is an investment in the future of America's greatness in space and the young men and women of this nation who will be the leaders of tomorrow.

That, Mr. Secretary, was submitted and received by the Presidential senior staff, Cabinet officer Alfred H. Kingon, who is the Cabinet secretary and assistant to the President, Alfred H. Kingon, K-i-n-g-o-n. He is immediately under Patrick Buchanan.

Now, what leaves us to wonder and still pursue this is the action of course of the White House itself. The White House first denied any reference or any thought or any tinge that the President would refer to the teacher in space. As we Congressmen and Senators know, the President always has a pleasant gimmick at the end of his talks. He usually refers to an individual such as the graduate from West Point that came from Vietnam and was No. 1 honors graduate, or the hero that was saving people down here, the Air Florida crash in the Potomac, Lenny Skutnik.

As we all know, any time the President makes a State of the Union Message, we can count on some pleasant wonderful approach that brings everybody in America together and makes us proud of ourselves and what have you. And yet they had us believe that there was no idea whatsoever or any submission whatsoever concerning the Teacher in Space Program. The fact of the matter is, it was denied that any submission was made to the White House.

And we looked around here for a month until an ABC broadcaster finally got it. Then when they finally got it, they for the first time admitted that there was such a proposal. You see, it was 11:28. The President and all of the press was gathered in the White House for a pre-State of the Union briefing, and there was a denial that there was any thought of the *Challenger* whatsoever and any reference to be made there. And no, there was not even a copy of the talk.

And then when we got a copy of the talk, it left off the last page. And then we noted that, and then it came in and we found out, oh yes, the last page did include a reference to the shuttle. But what we find is something that is very difficult for this Senator to believe. And you are not the appropriate witness, in a sense, to confirm or deny, and I am not asking that you do. But we see that the President at the time of the *Challenger* explosion was ready to say that evening "We see the dream coming true and the spirit of discovery of 21-year-old Richard Cavolie. All his life he has followed the path of science and medicine. Today the science experiment begun in high school was launched on the space shuttle *Challenger.*"

Now, obviously there is no question in this Senator's mind that the President was going to talk about the *Challenger.* It is equally obvious to this Senator that if he ever was going to refer to the *Challenger* he was going to refer to Christa McAuliffe.

I cannot understand the reluctance of the Commission to ask people at the White House about it. Were any of the witnesses from the White House asked about that?

Mr. ROGERS. Senator, let me say that we have been concerned as a Commission about the thought that anyone called or made any intervention to encourage this launch. We took it very seriously. Obviously, there was a submission by Mr. Graham, as you mentioned, as there is by every department and agency when a State of the Union Message is to be delivered, that you submit information that you would like to have included in the State of the Union Message.

Senator HOLLINGS. Excuse me at that point, Mr. Chairman. Secretary Baldrige and others said they were not asked and did not submit any text. I heard what you are just saying. They told us—Secretary Baldrige, I have his letter here. He says he was not asked to submit any text.

But go right ahead, sir.

Mr. ROGERS. Well, I guess I was relaying my own experience. I certainly always did, hoping that there would be something in the State of the Union Message.

But in any event, because we did realize the seriousness of the rumor, we questioned everybody involved in the decision, anybody that would have had any effect on the decision to launch this vehicle. And we questioned them under oath, either by deposition or by an affidavit. And that means everybody.

And the answers without exception were that nothing like that happened. So that if there ever was any intervention—and I am not talking about whether somebody might have been affected by the knowledge that everybody was anxious to have the launch successful, and I am not talking about that, but I am talking about any intervention on the part of anybody. Everyone said no such thing happened.

I took very seriously your comments originally, and we had four FBI people assigned to us.

Senator HOLLINGS. You went to gumshoes?

Mr. ROGERS. We got high class gumshoes.

And we asked everybody to keep their ears and eyes open to see if anything like that had ever happened. And I do not know how many people we questioned.

Senator HOLLINGS. Did you ask anybody at the White House to keep their eyes and ears open?

Mr. ROGERS. No; we did not say that to the White House. But we did inquire from the White House, and we saw the exchange of letters that you had with the White House and so forth.

But let me just finish by way of saying, the way, as you know from your experience, that you find out if something happened is to ask the people who would have been involved, and we asked everybody who was involved in that decisionmaking process and they all said, no, it did not happen.

Then we questioned, as I say, hundreds of people, and we asked if anybody ever heard of the rumor or not. And except for a few that heard the rumor in the press, everybody said that nothing like that happened.

I sat down with two people who were most involved—that is Jesse Moore and Aldrich—and asked them man to man if anything like that happened. And I said: I know you have testified and you have testified in public; did that happen at all? And they said: Mr. Rogers, I promise you it never happened.

Jesse Moore said: I was so busy, I did not even know the State of the Union Message was on. He said: That is a Washington phenomenon; I did not even know it. He said: We were involved in this for 3 days, and I assure you nothing like that ever happened.

Then we got the telephone records of all the people we could get and checked them out, and we could not find any call that suggested this at all. And more importantly I guess, and this is the thing that convinces me that it did not happen at all, because I would be just as upset as you would be if anything like that happened, all of the people involved in this decision have been under intense pressure. They have been criticized all over.

Now, if they had been asked by anybody, anybody, to make this kind of a decision, the most natural thing in the world for them to say: Somebody told me to do it, somebody suggested it, somebody wrote to me. Nothing like that happened.

They have all said it didn't, and the most natural thing in the world, that when you are under intense heat yourself and pressure, you like to put the blame on somebody else. Nobody did that.

We asked Mr. Mulloy; absolutely not. All of these people, it would have been the most natural thing to say, sure, I blame so-and-so. It did not happen, and so I am convinced it did not. And I hope that the rumor dies. I hope it dies.

Senator HOLLINGS. Well, Mr. Secretary——

Mr. ROGERS. It is a little bit like I am trying to figure out what starts a rumor, and I heard a story the other day I like. In Northern Ireland they are having a parade and somebody yells to the mayor: Mr. Mayor, I hear there is a rumor out to kill you; what do you have to say about that rumor? And he said: I never heard of such a rumor. And the guy says: You have now. That is how rumors start, just somebody mentions it.

And of course, in this case, because it was the juxtaposition of the President's State of the Union and the launch, which was not prearranged, it is natural for the rumor to start. But I am absolutely convinced that it is a rumor, and I just hope that it does not continue to live on.

We will make everything available to you, Senator. You can look at all the files and look at all the testimony. And I just hope it does not continue.

Senator HOLLINGS. Well, Mr. Secretary, most respectfully, why did you not ask somebody at the White House?

Mr. ROGERS. We did.

Senator HOLLINGS. Well, I do not see any White House witnesses listed.

Mr. ROGERS. We did not get involved in that and I do not think we should, because the White House assured us and the President said so in public in his television program, nothing like that happened. And I certainly did not feel and I do not feel now that we should go around summoning people from the White House, because there just was not anything like that that happened.

It is a little bit like trying to investigate a paternity case, going around asking people who is responsible, but there is no baby. It never happened. There is no baby in this case.

You have got to have somebody who says, I think there may be some evidence. There is no evidence in this case, and if people keep talking about it some people out there in the public are going to say, maybe there is something to it. There is not. There is not one scintilla of evidence.

Senator HOLLINGS. The baby in this case, Mr. Secretary, again most respectfully, is the explosion itself.

Mr. ROGERS. That is not the baby. That is not the baby.

Senator HOLLINGS. The baby in this case is the explosion itself, and you found pressure. In addition to the O-ring defect, the scientific or technical fault, there was also the human fault. You expressed it by way of communications. You express it by way of procedures of safety and everything else.

This Senator happens to believe there was individual fault and we will fix it in our hearings, hopefully, because I think it really promotes safety.

But let me get one answer before I go to your other logic. The one answer that I wanted in who did you interview at the White House?

Mr. ROGERS. Well, we did not as a Commission interview people. We talked to the White House about the President's State of the Union Message. We found out the same thing you found out.

Senator HOLLINGS. But there is no statement.

Mr. ROGERS. That is right. We are not going to—we did not. We finished our work, and of course if this committee wants to do that it has every right to do it. I would hope that in the interest of public knowledge about this, that the rumor that everybody else has seemed to drop—I mean, nobody in the press has even asked about this for 2 months.

And with all the people in the press who were so interested, if there was a bit of evidence of that kind they would be questioning us all the time. And I just do not think there is any evidence of that kind.

But I do not want to keep talking about it. If you feel that you have enough evidence to proceed, please feel free to do it. You are a Senator. You have every right to do it. Go ahead.

Senator HOLLINGS. But you did not ask anybody at the White House?

Mr. ROGERS. Not specifically.

Senator HOLLINGS. I think Dr. Keel might have a suggestion of some names. I am looking at page 209, where you list the interviews of outside pressure to launch, and I do not see any.

Mr. ROGERS. Here is a written response from the White House. We asked them. I believe their response is correct. We put it in the record. They say nothing like that happened.

Senator HOLLINGS. I appreciate it. Now, who is that by?

Mr. ROGERS. Mr. Jay Stevens, Deputy Counsel to the President. And he responded to the Commission's request, and here it is.

[The letter follows:]

THE WHITE HOUSE,
Washington, DC, April 29, 1986.

Mr. R. RAY MOLESWORTH,
Presidential Commission on the Space Shuttle Challenger Accident, Washington, DC.

DEAR MR. MOLESWORTH: In response to the requests made in your recent telephone conversation with Richard Hauser, I am enclosing copies of the following:

(1) March 20, 1986, 1986 letter to Fred F. Fielding from Senator Ernest F. Hollings;

(2) March 27, 1986 letter to Senator Ernest F. Hollings from Fred F. Fielding, with attachment, a copy of the January 28, 1986 draft of the State of the Union Address as given to ABC Nightly News; and

(3) A copy of the final version of the State of the Union Address as delivered on February 4, 1986.

You also requested a copy of any part of any draft of the State of the Union Address that included a reference to NASA. I have been advised that no drafts of the address referenced NASA. One draft, however, did mention the shuttle, in connection with Richard Cavoli, one of the several American heroes recognized by the President in the Address. The draft read in relevant part:

The dream lives. And as long as it is real, work of noble note will yet be done. We see the dream coming home in the spirit of discovery of 21-year-old Richard Cavoli. All of his life, he has followed the path of science and medicine. Today the science experiment he began in high school was launched on the space shuttle Challenger. Richard, your work could reduce harmful radiation effects of X-rays on patients; it could enable astronomers to view the golden gateways of the farthest stars.

As you will note, the language ultimately delivered by the President was:

We see the dream coming true in the spirit of discovery of Richard Cavoli—all his life he's been enthralled by the mysteries of medicine. And Richard, we know that the experiment that you began in high school was launched and lost last week, yet your dream lives.

You also inquired whether there had been a proposal to have the President speak via telephone hook-up to the Challenger astronauts during the State of the Union Address. I have been advised that consideration was never given to having such a hook-up for the State of the Union Address.

Finally, we have discussed with Messrs. Rick Davis, Gerald May, and Al Kingon, and with Ms. Ann Foreman, their recollections of the telephone conversations or meetings they had with Dr. Graham in the days immediately prior to the shuttle disaster. Mr. Davis advised that his January 17 conversation with Dr. Graham was a courtesy call he received from Graham. Graham sought to introduce himself to Davis, who was to become Graham's contact person in the White House Office of Cabinet Affairs. Ms. Foreman recalls that her conversation of January 24 with Dr. Graham concerned an invitation Dr. Graham extended to her to attend the shuttle liftoff, then scheduled to take place over the weekend of the 25th and 26th of January.

Alfred Kingon advised that although he received a call from Dr. Graham on January 24, he had Rick Davis of his staff return the call. Davis advised that the call concerned the announcement of a NASA personnel action (Jess Moore as Director of Space Flight Operations).

Col. Gerald May advised that his January 21 appointment with Dr. Graham was at the request of Admiral John Poindexter, Assistant to the President for National Security Affairs. It provided May an opportunity to meet Graham and explore with him matters he, Graham, wanted to discuss in a future meeting with Poindexter. None of those matters concerned the Challenger, nor was it otherwise discussed.

I trust you will find the above responsive to your inquiry. However, do not hesitate to contact me if you have any further questions.

Sincerely,

JAY B. STEPHENS,
Deputy Counsel to the President.

Senator HOLLINGS. Well, we appreciate that.

Now, Mr. Secretary, again a little bit further. Mr. Kingon, you did not think to ask him what he did with that suggestion that went to him. Would it not be logical, looking at all of the witnesses, you say your Commission went into 300 different scientific tests, you interviewed hundreds of witnesses.

Mr. ROGERS. Senator, I accept the criticism if that is what you want to do. I accept it. I do not think it is valid. I accept it, though.

I respect you. I do not think there is a bit of evidence that anybody tried to influence this launch, and if we keep talking about it a lot of people will believe it happened. It did not happen.

If you can prove it, I will apologize to you. I will come back here and apologize if you can prove anything like that happened.

Senator HOLLINGS. Oh, yes, yes, I imagine you would. I do not know of any evidence. I never have said there was evidence. But I thought it was logical and our responsibility is there to follow up a logical thing.

I cannot see the President of the United States in the State of the Union message with a submission by the head of NASA suggesting a direct reference to Christa McAuliffe on the *Challenger,* disregarding that and including a reference to a student scientific experiment on the *Challenger.* That puzzles me. That is why I asked the question. That is the one bit of evidence that I have, that I want to clear up.

There is nothing wrong with clearing it up, or getting irritated or annoyed or saying if you later find any evidence you are going to apologize, none of that at all.

Let us go to Dr. Graham and bring in his own pressure. Now, if I am the head of NASA and I have made this particular submission to the White House, what about Dr. Graham and Phil Culbertson? I am Phil Culbertson, the No. 1 man at the Kennedy Space Center on the day of launch. I know I have signed off on a recommendation that starts off saying, "Tonight while I am speaking to you." And so I am Phil Culbertson and I have got already submitted—I am the head man of NASA down at Kennedy Space Center. So as the head man, I have already submitted "Tonight, while I am speaking to you, a young elementary school teacher, Christa McAuliffe from Concord, New Hampshire, is taking us all into the ultimate field trip," and on and on.

Now, I know, trying to get that off—I've already submitted it. I do not know whether the White House is going to do it or not. I do not have any idea. I have not received any calls, as you indicate, or anything else like that, and no individual to call.

But is it not natural for me to assume that, having made that submission to the White House, I would like to be able to carry it out? And so, like the press jumps on NASA and blames them for an unlatched door, necessarily the White House would jump back on me and say: Look, you had us all ready to go and you delayed it again.

So I brought really pressure on myself, is that not correct?

Mr. ROGERS. I guess so. Here again, I do not want you to think that I object to your asking the questions. And I know you have asked a lot. We have tried to answer. I just hope that people do not persist in perpetuating this rumor that I think is baseless.

But I certainly do not object to your right to do it. I do not have anything else to say about it, Senator.

Senator HOLLINGS. What did you ask Phil Culbertson? Did you ask Phil Culbertson or Dr. Graham if they had that in their statements?

Mr. ROGERS. Sure.

Senator HOLLINGS. Well, you did think to ask them. So the question is not totally unfounded.

Mr. ROGERS. No; we asked everybody we could find about whether anything like this happened, and everyone says no.

Senator HOLLINGS. And you do have a statement from Phil Culbertson, and you do have a statement from Dr. Graham?

Mr. ROGERS. Yes, we do.

Senator HOLLINGS. Now, with respect to your logic, which intrigues me, that somebody would come out and indicate blame, is it not also logical that if no one is fired, no one is dismissed, then there is no one to blame? It is a sort of a sweetheart deal. Everybody goes their way and everybody is responsible and nobody is responsible.

I believe if I had dismissed two or three down the line, then if there had been pressure, logically they would have come forward and said: Wait a minute, do not set me aside; I was asked to.

No one says that and you say, I do not have any evidence of that. But is that part of the lack of finding any individual responsibility in this Commission's report?

Mr. ROGERS. No.

Senator HOLLINGS. Let me ask on another subject. On page 200, Mr. Secretary—and I have some other things, but I did not know if I will get the time this afternoon. But it seems important to me that you recommend with respect to landing, but not with respect to launch.

On page 200 you say: "Committing to a specific landing site requires the landing area weather be forecast more than an hour in advance." That is the landing area weather be forecast.

But if you turn, if you please, to page 37, where it is a very interesting part of the report, showing exactly what concerns this Senator here, you find what we learned at the very early stages, where there was a puff of smoke and then for 26 seconds there was absolutely none. It sort of resealed itself.

At page 37 at the top here, at 0.67 or six-tenths of a second, "confirmed smoke above field joint on RH SRM." Now, between that time and down at 58.7 seconds, Mr. Secretary, we get the first evidence of flame. In between there, at 36.99 seconds, you get the roll, the yaw, the attitude response to wind.

And we are told that winds of hurricane force hit that shuttle, and it seemed perhaps that they did have O-ring problems and it did seal back itself, but when it hit that hurricane force wind or wind shear, however you would characterize it, that it then came apart. The flame emerged and hit the booster and then the explosion and the tragedy itself.

So do you not think it is just as important for the launch as on the landing that we have within the hour preceding launch wind shear information, and other data?

Mr. ROGERS. Yes, I certainly do, Senator. And we had quite a lot of testimony on that subject. They are attempting to improve their capability to predict weather at the site.

They have a pretty good system now, but it is not satisfactory and they are trying to improve it. They launch balloons and they have planes going up, and so forth. But I think NASA accepts the proposition that you just proposed, and that is that they really

have to do better in predicting the weather at the launch, and that is important and that is one of the things that we have suggested.

Mr. ARMSTRONG. I might add, Mr. Chairman, and with your permission, Senator, that you characterize them as hurricane force winds, which is quite correct. Yet you and I and others in this room fly in hurricane force jetstream daily. These were not unusual winds at all for the winter. They were very standard. They were well within the design envelope of the vehicle.

Senator HOLLINGS. You say they were not hurricane? I have got the report.

Mr. ARMSTRONG. It does not say hurricane force winds in here, that is quite correct. If you say winds in excess of 90 and 100 miles an hour, they certainly were. And it is expected.

This vehicle is designed to handle those winds. As a matter of fact, the loads through the wind shears as we have recalculated in our analysis were well within the design envelope of the vehicle, and as a matter of fact they were considerably lower than the loads during the initial phases of the boost.

So this was not surprising, those parts of the loads as developed by the wind shears were not surprising. Now, there was a small difference from previous flights. The size of the loads was not different, but the duration of the loads was somewhat longer than had previously been experienced, giving evidence to the fact that shears existed, although not greater in magnitude, to somewhat higher altitudes than were measured on previous flights.

Senator HOLLINGS. Thank you, Mr. Chairman.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

There are three areas that I want to get into. First of all—and one is a new subject that we have not discussed before, at least in this hearing. And that is that I am very concerned about making sure that these recommendations that you have worked so hard to develop are carried out fully and properly.

And that is a difficult job by itself because, as you say, it has budget implications and these are complex questions. Certainly the engineering change issues have to be resolved. We do not quite know yet how those are to be resolved, and so forth.

I want to raise with you a concern that I have about just the structure of decisionmaking, because I think, while this may not be right in the center of your assigned mission in a sense, if the work you have done is not fully implemented then the job is not finished.

I am concerned that it is essentially now the middle of June and a very busy congressional session. We have got the tax bill on the floor, which is highly technical and involved, as you know. We have got other major legislative items, with the budget and the Gramm-Rudman pressures and all the appropriations bills yet to pass. We have got the trade legislation coming.

And I would say that we probably have at the most 60 legislative days left to work with, recognizing that the desire of the Congress will be to end about October 1, because there is an election early in November.

As a result, these questions on NASA just by virtue of the timing are, if you will, somewhat behind the curve in terms of these other legislative priorities that are already center stage, so to speak.

And I am concerned as well that there is a very divided jurisdiction over NASA issues. You have got a lot of players, you have got different committees in the Congress, the authorizing committees and the appropriating committees in the House and Senate. You have got NASA itself, which is going through a lot of internal change and reorganization and new leadership coming in.

You have got a policy group at the executive branch level, the SIG group, that is struggling with some of the future space policy questions, and so far we have had no recommendations from them.

And we are very late in the legislative budgetary process for this year. And all of these things I think complicate and confound the implementation of these decisions. Even if the President in very strong language says, I want everything that is in that report carried out, no ifs, ands, or buts—and I hope he will say that strongly. But if that signal goes out, getting it all done in the face of these other kinds of pressures and responsibilities is very difficult to do.

It has occurred to me that in the same fashion that you have had an ad hoc group come together to accomplish a very difficult piece of work in a very compressed timeframe, that maybe what we need here is some kind of an equivalent task force effort for a limited period of time, maybe only through the end of this year and maybe only through the legislative session, that would enable the key people on the authorizing and the appropriating committees of the Congress and on the policy level in the administration and at the top level in NASA to maybe be able to work together as a working group to see to it that all of the collateral issues here—the funding issues, the policy issues, the fix issues, all of which we have some part in together—but that we can somehow find a way to work cooperatively and put the branch of Government constraints in a sense somewhat to the side and have absolutely no partisanship in it whatsoever, and in a sense try to rationalize a course of action that allows us to not stay behind the curve, if you will, to sort of catch ourselves up here, put these decisions together and make sure we have got a workable plan where all of the pieces, including the budgetary piece, is worked into place.

And then it seems to me we would have a much stronger chance of making sure that all of this work that you have produced here is in fact carried out properly and on a timely basis.

Absent that, I am concerned that NASA and these questions are difficult enough, they are diffused across a broad enough jurisdictional area, that they are going to be buffeted by a lot of different pressures. You are about to disband as a Commission and so you are not going to be there, in a sense, as a presence to help shepherd things ahead.

And I would like to put that idea on the table today for you to think about. I talked to Dick Truly yesterday. He seemed to like that idea as a way to try to enable us to just work together.

I mean, there is nothing wrong with the Government working together once in a while. And it seems to me this is an appropriate time for it, and we are in kind of an emergency situation. In any

event, I feel strongly that we would gain a lot and I do not see what we would lose in the process.

And I would like to recommend it to you, so that the ball can get carried on down the field here and not just in a sense sit on the field while time passes. So I just wanted to say that to you, and then I wanted to go back to a couple of other areas.

Mr. ROGERS. I think you certainly are thinking along the right line. I want to think about how just to do it, and I am not sure I should make a recommendation other than to say that it is going to take a special emphasis and impetus, I think, to get the space program going again.

And I think that Jim Fletcher and Dick Truly and others are going to need some support. And so it is going to be awfully difficult for them to proceed. I mean, there is going to be a natural tendency to keep harping at them and say, why did not this happen, why did you not do that? And of course, that can be destructive if it goes on too long.

What we tried to do in this report is to get it all behind us, lay it all out on the table and to say that the Nation has done it well and now let us get on with it. And I think Congress has a very tough problem to deal with.

And certainly what you have suggested is a way that it might be pursued.

Senator RIEGLE. Well, let me just make one other comment and then move on, and that is that I know that Senator Gorton, chairman of this committee, and I and others who are working with you have tried to establish that manner of approach to these issues, so that we could in fact work them through.

And as you say, in a sense the investigative effort is now behind us and the finding of cause and the recommendations are now in front of us. And carrying them out, of course, is the next leg of the journey here.

And I am just very concerned. And you have been around this town a lot longer than I have, but I have seen an awful lot of good intentions sort of get stymied because there is the lack of critical mass focused behind them. And I am concerned about when you as a group disband, because we then break into a fragmented structure, and I am afraid that is just the wrong way to do it.

At this point, I think we need a consolidated structure, at least for a period of time, to try to work through the decisions that are right in front of us, so that we can really in a sense get things moving again.

Mr. ROGERS. I certainly support that concept. And I also want to say again how much we appreciate the Senators and the chairman's and your cooperation, Senator Gorton, and yours, in every aspect of this.

I know that you came down and watched our proceedings and sat through two or three days of hearings, and we appreciated that. And we certainly appreciate the chairman's cooperation, and all the members of the committee have been very cooperative, and I think it has been in the national interest.

And I think if we all work together in the future—I hope to get out of the public position, but I certainly would do all I can personally and privately to help the space program, because I firmly be-

lieve in it and I think it is in the national interest to get the program going again and to take our position in space, which is certainly important for the future.

Senator RIEGLE. Well, thank you.

Let me go back now to two other areas. As I understand it, it was late in the conduct of the investigation, I think it must have been about early May, just about a month ago, that in your investigative work you found a memo of some sort at Thiokol that indicated that this O-ring problem was very severe.

And I gather there was an exchange of letters and launch constraints established, and it was when you discovered that letter in the Thiokol files that you then tracked it back to NASA. And there was such a high level of concern about whatever was in that particular document that you then on May 2 held a special closed executive session centering on that memo and its implications.

Am I correct in that?

Mr. ROGERS. That is correct.

Senator RIEGLE. Now, the question in my mind is that I was really shocked that it was not until that late in the investigative effort, when all of the work was being done, the President had asked people to come forward, and so forth, that that very material piece of information had not been forthcoming. I mean, and you found it, and I gather somewhat by chance.

You were trying to determine information, but the memo turned up at Thiokol, is that correct?

Mr. ROGERS. That is correct.

Senator RIEGLE. And then you were able to take it from that point.

I, for the life of me, cannot understand why that kind of a memo would not have been volunteered to you by NASA early in the game. And I would like to know why it was not, or what you have concluded about that.

Mr. ROGERS. Well, I do not think that the people that were in charge of the investigation—and I am talking about Dick Truly particularly—knew about it.

Senator RIEGLE. I am sure that is right.

Mr. ROGERS. So that insofar as they were concerned, they cooperated 100 percent with us on everything. In fact, they volunteered all kinds of information we did not ask for. And so there was no complaint at all. Quite the contrary, we think they did a marvelous job in cooperating with the Commission.

As to the second part of the question——

Senator RIEGLE. Just on that point, somebody knew about it and somebody did not bring it forward. Who would that have been?

Mr. ROGERS. Well, the people at Marshall.

Senator RIEGLE. But who is that? I mean, people at Marshall?

Mr. ROGERS. Well, I am not sure. I mean, Mr. Mulloy would be one. Certainly we asked him about it, and there is sworn testimony about why he did not do that.

Senator RIEGLE. So he would have had the opportunity then, prior to when you found this letter at Thiokol, to have seen to it that this letter was given to the Commission?

Mr. ROGERS. Sure, absolutely.

Senator RIEGLE. But it was not given to the Commission?

Mr. ROGERS. It was not given to the Commission.

Senator RIEGLE. Do you have any understanding as to why that was withheld?

Mr. ROGERS. No. As I say, he tried to explain it, not very satisfactorily. But there are others at Marshall that must have known about it, too.

Senator RIEGLE. Who would they be?

Mr. ROGERS. Well, I do not know. I am not sure. Maybe Kingsbury.

Dr. KEEL. Well, certainly everyone in the shuttle project office, level III at Marshall, should have been aware of the documents.

Senator RIEGLE. Who would that include?

Dr. KEEL. Well, Mr. Reinartz of course was project manager; Mr. Mulloy, Mr. Wear; all of their cohorts who worked for them; also people in the science and engineering directorate at Marshall, particularly in propulsion, the propulsion division and the solid rocket motor branch of the science and engineering directorate.

Senator RIEGLE. So there were a number of people. I would gather that may number a dozen or two dozen people that would have been aware of that letter and that circumstance?

Dr. KEEL. Presumably even more than that. People in the safety, reliability, and quality assurance area who actually put that constraint on should have been aware of it.

Senator RIEGLE. But that was not made—that knowledge did not come to the attention of the Commission until on or about May 2 or thereabouts?

Dr. KEEL. No, it was a little before that, Senator. It was late, but it was early April. We were, as you know, conducting a number of interviews and gathering documents, reviewing those documents, evaluating them. So around early April we found the memorandum at Morton Thiokol that referenced this problem of O-rings in a problem assessment report.

And then in following up on that memo we went to Marshall and actually found more, and in those were documents relative to the launch constraint itself.

Senator RIEGLE. I am really distressed about that, as I think the Commission was.

Mr. ROGERS. We expressed our distress, as you remember, and we made the testimony public.

Senator RIEGLE. And I am wondering now, is there any clear understanding as to why that information was not volunteered on a timely basis? It gives the appearance of having been information that in effect was withheld, or at least it was not offered to the Commission and you only found it by relentless digging.

Mr. ROGERS. Not beyond what I have said.

Senator RIEGLE. So there is no explanation as to how this came about, I mean as to why you were not given this information?

Mr. ROGERS. That is right. As I say, the testimony by Mr. Mulloy, and others maybe, is available and they try to explain it. It did not sound to me like a good explanation.

Senator RIEGLE. But I am clear on that. I guess what I am trying to get at, though, is this long length of time when the Commission was charged by the President to do its work, you were out doing your work, people know they were to present relevant information,

and here was a critical piece of information in writing, known about by a number of senior people at Marshall, and that was not brought to the attention of the Commission for several weeks.

I mean, I gather—how long would it have been, Dr. Keel? I think 2 months?

Dr. KEEL. At least 2 months.

Mr. ROGERS. I think the explanation they gave—and I might have to go back and refresh my recollection—is that they thought we knew about it. I think that was their explanation.

Senator RIEGLE. Well, that does not wash, though, does it?

Mr. ROGERS. No, it does not. You and I agree. I mean, I agree with you exactly. I agree with you.

Senator RIEGLE. Well, the reason I press the point is that to me it speaks to a very serious problem at Huntsville. I think it speaks to an issue of lack of full disclosure, a lack of telling the whole truth on a timely basis, and I am deeply troubled about that. And I gather you are as well.

Mr. ROGERS. Absolutely.

Senator RIEGLE. Well, it seems to me—and I find it hard to imagine that 20 or 30 people would have had knowledge of that kind of important information and would have withheld it unless they were asked to. I mean, it almost suggests to me that the word was out that people were to keep this to themselves.

Mr. ROGERS. I would not want to draw that conclusion, but it is one of the things you might conclude. I think you will find when you question them that they will all say that they thought we had it. But that is not a very good explanation.

Senator RIEGLE. Well, it certainly is not a sufficient explanation for the people at the top, who would have an affirmative obligation to make sure you had it. Would that not be a fair statement?

Mr. ROGERS. That is right.

Senator RIEGLE. So I cannot conceive of an excuse as to why there could be any justification for that not having been brought to your attention. And I am glad the Commission was persistent enough that you unearthed it through an unorthodox pattern of activity.

But you should not have had to get it that way, and I am bothered about that, and the people who withheld that information I think ought not to be in responsible positions in the future. I mean, how do we guard against that kind of thing happening again, if people who conducted themselves in that fashion are still around?

I mean, I would think that there is always the concern that they might conduct themselves that way again.

Mr. ROGERS. I agree with you.

Senator RIEGLE. Well, I guess it is important to know that, because then it helps us, I think, in sort of moving forward, because the Commission now goes out of business.

Mr. ROGERS. I think you are pointing up one of the advantages of this kind of an investigation and this kind of a report.

Senator RIEGLE. Let me ask a slightly different question, and that is were there any other witnesses in the course of the investigation that gave the Commission either misleading testimony or what you learned after the fact to be incomplete or something less than an honest answer?

Mr. ROGERS. I do not think I would want to characterize it that way. I would say that in the early part of our investigation there were bits of testimony, bits and pieces of testimony from time to time which I would characterize as less than forthright. Not that it was totally incorrect, but some of it looked as if there was an effort to smooth over a bad situation or say it in a way that made it appear less important than it really was.

And I think that as we went along we were able to find out the significant facts which did not appear at first blush. And now I cannot point to specific testimony today, but we are going to have all of the testimony made available to the public published, and I think when students go back and look at the testimony and have a chance to analyze it, they will probably come to the conclusion that some of it was not totally forthright.

I think it is all there now.

Here again, I want to say in terms of assessing blame or pointing out who did these things, that it seems to me has to be done by the Administrator at NASA. We have laid it all out. We were not passing judgment on people. We were not asked to.

That is for the Administrator to do. Whether he wants people in these spots and what decisions he makes about them is his job. We were not asked to do that and I do not think we should have done it, and I think the facts are all there.

NASA itself has to deal with them. I have confidence they will deal with them properly. And it is tough for him. It is tough for Jim Fletcher, it is tough for some of the others. These people are able men who have been involved in the program for a long time. They have had a fine record of success.

And it is easy enough to condemn them and damn them and complain about them and so forth. We have exposed it all. And I think it is perfectly proper for this committee to ask questions of the new Administrator. I do not think we should have to answer them.

Senator RIEGLE. Well, I do not think we are approaching it in a condemnatory fashion here. I think we are just trying to establish exactly what was learned, and so forth.

Mr. ROGERS. No, I understand. I was not complaining.

Senator RIEGLE. And I want to say as well that I greatly appreciate your own leadership in persisting in the face of incomplete answers and answers that I think were designed to deflect or perhaps mislead in certain instances.

I know the times that I attended the public sessions I thought that is what I was hearing by the witnesses, and I felt a number of times when you interjected personally to compel witnesses to address specific questions and to not slide off that those were the times where we got some of the most important information that we got.

And I think anybody watching and listening to those hearings would have sensed your own frustration at certain points that, without pressing, you would not have gotten the truth out of some of the witnesses in the form that you needed to have it.

Mr. ROGERS. It was not particularly pleasant duty, I must say.

Senator RIEGLE. Well, it was not, and it should not have been required in that fashion, I would say, of people who work for the

public. I think public officials have an obligation, particularly in a matter of this gravity where lives were lost, and so forth, to be absolutely truthful and forthcoming.

And I think there were instances where that was not the case, and that is troubling to me and it is troubling to me in the sense that I just do not want to put anybody in the future at risk. I do not want another astronaut going into space if there is anybody in a managerial position of responsibility who thinks that way or who works that way, or that there is even any kind of an endemic problem along those lines in any given space center or what have you.

I think that needs to be cleaned up and it needs to be cleaned up completely. One of the reasons I supported Jim Fletcher's nomination is that I felt that he was strong enough and seasoned enough and tough enough and enough of a person who is concerned about the reputation and future success of NASA that he would be able to go in and make the changes that were needed at the managerial and personnel levels.

Time will tell whether that is right. That is my judgment, and his actions will have to indicate whether that confidence is well founded. I think it is.

I want to raise one final issue with you now, and that is with respect to the full scope of your recommendations. I understand from your report that a number of members of the Commission felt that certain mechanical problems with the Space Program needed to be identified and put on a short list. And I gather you had about 50 different recommendations suggested by the Commission members as a whole.

You sorted through those as a Commission and you ended up coming down to a list, I think, of nine or so that you have decided as a group to put forward to us. Is that correct?

Mr. ARMSTRONG. I cannot quote that number, sir, but the process is true, yes.

Senator RIEGLE. So in other words, I think it would be useful for us to have the remainder of the list, and I am sure you have it. I do not want to necessarily go into it this minute, but I think it is important that these recommendations be submitted to the committee so we can see what members of the Commission felt were important enough to flag. I would like to see that complete list and not just the winnowed-down version.

Can we have that full list?

Mr. ROGERS. Sure.

Senator RIEGLE. I will just end with this. Am I correct in thinking that the Commission is saying that any criticality 1 items that are outstanding have to be fixed before the shuttle flies again or not?

Mr. ARMSTRONG. May I answer that, Senator? As you know, that is a long list of things, and some inherently will always be criticality 1. If the wing breaks off, that is the end of the flight. The wing has to stay on. There are a lot of things that have to stay together in order to have a successful flight.

We have suggested that the entire list be reviewed and every one, that its criticality status be evaluated to see if the previous judgments were correct or are still correct at this point in time,

and give the opportunity for people who have ideas how any of those might be improved to do so.

Senator RIEGLE. Is there a list of items that the Commission has decided have to be fixed? Do you have a minimum list of things that you say, based upon your study, have got to be fixed before the shuttle flies again?

Mr. ARMSTRONG. I think the only thing we really say is that the solid rocket booster has to be fixed. The other items have caveats on them associated with the recommendations that say, before such and such happens, this has to be done.

And it does not necessarily mean before flight, although we think that some of these are of such a nature that in this interim period they should logically be completed.

Senator RIEGLE. I think it is very important that you put as much light on that as you can for us. I mean, we are just in the process of reviewing the Commission's report, because as you know we just got it yesterday, and you were kind to give us copies yesterday.

Mr. ROGERS. May I comment?

Senator RIEGLE. Please.

Mr. ROGERS. I just want to make a comment on this criticality 1 and 1-R and 2 and 2-R. What was totally unsatisfactory to me in listening to the descriptions of these was the meaning of them and the effect of the designation.

For example, this joint was considered for a while to be criticality 1-R, which meant that they thought that if one of these seals failed there was another backup seal. There were two O-rings. So for a long time they operated on the theory that there was redundancy.

And then because they had trouble with it and they reviewed it, they decided that criticality designation was not correct and so they changed it. So they changed it to criticality 1, which meant—and it said so—this is a criticality 1 item and if it fails, if that joint O-ring fails, it means loss of mission and crew.

Now, that should have alerted everybody in dealing with this joint in all the discussions about it that it meant exactly that. Yet you will see when you read the report and the testimony we took that Marshall seemed to, and some of the people at Thiokol seemed to, operate on the basis that there was still redundancy.

And they, in justifying why they agreed to the launch, they say: Well, even though it was criticality 1, we in effect thought there was redundancy. And so they weren't operating on their own criteria.

And so what we have asked them to do is review all of these, not only criticality 1 but all of them, to see if they make sense, to see if there are things that should be corrected and improved, or are they things, such as Neil suggests, that when you say criticality about a wing it does not have any meaning. Obviously, if the wing falls off you know what is going to happen. So that designation for the wing does not mean very much.

Designation for the joint means a lot. It means you can fix the joint. So what we have asked here in this recommendation 3 is for them to review it very carefully and have an audit of all of these.

And then we said there has to be an audit panel appointed by the National Research Council to verify the adequacy of the effort and report directly to the Administrator. And so we hope that this recommendation, if carried out, will clear that up, so that everybody in the system knows that if it is criticality 1 and there is any slight failure, or suggestion of failure everybody takes it into account and works on that basis.

And I hope they will do that. I think this is a very important recommendation.

Senator RIEGLE. I was just going to ask if President Reagan, on that very point—and then I would yield to Senator Hollings because he has a question on that—has President Reagan said to you directly as the Commission Chairman and other members that he has pledged himself to carry out these recommendations, or is he in the process of studying the report and will decide that later?

Mr. ROGERS. It is the latter, but he certainly was very positive in the meeting he had with us. I mean, he could not have been more supportive and positive. He did say that he wanted to review it carefully and he had not had the opportunity to, and that he would make a statement on it very soon.

So we expect that is forthcoming.

Senator RIEGLE. That will be a very important statement. We will look for that.

Senator Hollings wanted me to yield.

Senator HOLLINGS. Just one other point. The hour is late and the Chairman has been testifying since early this morning, I understand.

But on that criticality 1, Mr. Secretary, you say that they operated on the basis of criticality 1-R, that it had a redundancy. On the contrary, on page 85 you refer to that L-1 mission management team meeting that took place on the 25th and they made the flight readiness review. And Mr. Mulloy testified as follows regarding the flight readiness review record about O-ring concerns:

Chairman ROGERS. Why was that not a cause for concern on the part of the whole NASA organization?

Mr. MULLOY. It was cause for concern.

You see, he was not treating it as 1-R.

It was cause for concern.

Chairman ROGERS. Who did you tell about this?

Mr. MULLOY. Everyone.

Chairman ROGERS. And they all knew it at the time of 51-L?

Mr. MULLOY. Yes, sir. You will find in the Flight Readiness Review record that went all the way to the L minus 1 review.

Then the language:

It is disturbing to the Commission that, contrary to the admission of Mulloy, the seriousness of concern was not conveyed in Flight Readiness Review to level 1 in 51-L Readiness Review.

So he wasn't treating it as redundancy.

That fellow either misled or lied about this thing. And I know he rode the devil out of Allan McDonald. And there is an important point. If we are really going to get safety, because there is an element of human nature, if Senator Gorton is in charge of safety around here then nobody has to worry about it; we know he is in charge.

But if all of us have a sort of mutual responsibility, particularly in an organization that is similar to the military, and NASA is, then you have got to look out for your man. Every commander does not have a safety officer. As you and I both know, everybody is sort of responsible for it.

And that does not mean that nobody is. Everybody is. That is a fundamental that has given us all wonderful confidence in NASA.

I never heard of an O-ring on this subcommittee, but I do not feel badly. Like you said, Dick Truly, he has gone up and there was a defect in the one he flew. He did not hear about it. The astronauts did not hear. We did not hear about this or anything else of that kind.

That is one of the real important parts of your report, that has got to come out. But when it comes down about the testimony to the effect that Mulloy, for example, thought it was a redundancy. He said: Oh, no, I knew about the concern and I reported it all up. He moves about with those statements in his hands, and I watch him and I hope we can get him later on.

Thank you, Mr. Secretary.

Mr. ROGERS. Thank you very much, Senator.

Senator GORTON. You have been through not only a productive time, but a very tiring and exhausting time. Not just this afternoon, of course, but all along.

Once again, I would like to thank you, Mr. Secretary and Mr. Armstrong, and through you to the other 11 members of the Commission.

I think it would be appropriate to compliment Dr. Keel as well. We have emphasized how much of the work the Commission members did themselves, but I know they were well served by the staff.

Members of the committee and subcommittee will have additional questions which we will submit in writing.

Senator HOLLINGS. Will the other members be available for us, too, the other members of the Commission? I saw Mr. Hotz this morning and was very impressed with what he had to say. I got more out of Sally Ride's facial expressions than anything else. You could tell the witness was not telling a true statement when you looked at her.

Mr. ROGERS. She was really a wonderful contributor.

Senator HOLLINGS. But will they be available for the committee?

Mr. ROGERS. They are going to hate me if I say yes. But I think they will.

Senator HOLLINGS. I am not trying to belabor them, but I think they can be very helpful.

Senator GORTON. I simply wanted to ask how long Dr. Keel will be on the job and if there will be a staff to answer some of the questions that we will submit.

Mr. ROGERS. Before you answer, let me tell you that he did a really terrific job, and this whole documentation systems is his idea and he put it into effect. And he does not want to be available for long, but I will let him answer.

Dr. KEEL. How about until this afternoon?

I suspect it will be a matter of weeks, Senator. We have four more volumes to report, as well as transitioning all of the remainder of our documents into the archives.

Senator GORTON. We will try to get as many of our additional questions to you as promptly as we possibly can, and hope that, even when you are simply a pure citizen again, you will help us when we need that help.

Mr. ROGERS. We will.

Senator GORTON. In any event, we once again thank you for your marvelous public service.

The committee is adjourned.

[Whereupon, at 4:55 p.m., the subcommittee was adjourned.]

[The following information was subsequently received for the record:]

QUESTIONS OF THE CHAIRMAN AND THE ANSWERS

Question 1. The Commission concluded that Morton Thiokol reversed its original position and recommended a launch at the urging of Marshall Space Flight Center.

A. Are you aware of any other instances when such "pressure" by NASA, from *any* of its centers, might have forced a contractor to reverse its original launch recommendation?

B. Do you believe that by the very nature of the contractor/customer relationship, such pressures, however, subtle, will always exist in the process?

Answer 1. A. The Commission is not aware of any other instances where the contractor reversed a "no launch" recommendation at the urging of NASA.

B. The very nature of the relationship will always make the system susceptible to such pressures unless steps are taken to assure proper communication or critical launch related recommendations—whether reversed or not—to all levels of management.

Question 2. In April 1984, Marshall and Morton Thiokol established an O-ring task force to investigate O-ring charring.

A. What conclusions did the Commission reach regarding this internal task force and its progress?

Answer 2. The Commission concluded that the task force was not as effective as it should have been in expeditiously achieving a solution to the problem. This conclusion is based on complaints about the task force's progress in internal Marshall and Thiokol documents, as well as progress reports from the task force.

Question 3. It is clear that at the beginning, Rockwell had serious concerns about the likely effect of ice formation on the Shuttle and its launch facilities, yet nowhere is it clear to me that NASA and its Ice Inspection Team had similar concerns.

A. Was this Ice Inspection Team qualified to make the necessary assessments regarding ice formation and its likely effects?

Answer 3. A plan for ice inspection of the launch facility and Shuttle system had been developed and was followed by the Ice Team. The Team reported conditions to their supervisor who then assessed risk. This included the ability to predict potential ice impacts with the Shuttle thermal protection system tiles. The prediction method, however, did not adequately account for the influence of air currents caused by the main engines or solid rockets—the effects of aspiration—on the falling ice debris.

Question 4. Your report concludes that NASA's Freeze Protection Plan was inadequate.

A. How was it inadequate, and how could it be improved?

Answer 4. NASA's Freeze Protection Plan was inadequate in that water could not be completely shut down and drained from the launch pad while continuing launch preparations. The procedures called for a draining system to avoid freezing. This was not done since it would have delayed launch. Instead, to preclude frozen pipes and possible pipe ruptures, water was allowed to run. This resulted in massive ice buildup when the drains themselves froze and plugged.

Question 5. The Commission established an independent technical review panel to assist the Commission in its investigation.

A. What was the extent of this panel's involvement throughout the investigation and how did it function?

Answer 5. The Commission established an Independent Test Team of technical observers in early March 1986. The team was principally charged with overseeing the NASA and Thiokol tests and analyses designed to test various hypotheses concerning the cause of the accident and to establishing the sensitivity of Shuttle compo-

nents to various physical and operational factors. One matter of critical concern was the sensitivity of the SRB joint performance to low temperatures. The team also served to provide technical advice to Commission members and remained in existence throughout the Commission investigation. A report to the Commission of the Independent Test Team is being published as Appendix E to the Commission Report.

Question 6. Once again, we have been reminded of the risks of manned space flight, yet I doubt that we will ever be able to eliminate all risks. Nevertheless, we should strive to assess those risks as accurately as possible.

A. What is the Commission's assessment of NASA's Risk Assessment protocol, and what risk assessments had been made on the SRB's or its joints?

Answer 6. NASA does not use a probablistic determination of risk. Rather, the system is assessed from the standpoint of the acceptability of the failure of a particular component. In most cases, redundancy protects the Orbiter and crew. Where this is not the case, a formal waiver is required to allow operation and flight. There is no formal Risk Assessment protocol.

Question 7. A. After having examined NASA's Flight Readiness Review process, what, in your opinions, are the fundamental problems in this process, and how can they be corrected?

B. How can it be assured that problems at a Level III or IV Flight Readiness Review will receive proper attention at the same Level I Flight Readiness Review?

Answer 7. A. Incomplete presentations and a tendency to downplay the FRR as the program was declared "operational" were problems. A lack of detailed knowledge on all systems by key managers will perhaps always be a problem. The Commission believes that the structure of the Level I FRR, usually involving teleconferences with a large number of participants, may need to be examined to determine whether a different format could increase the amount of information and encourage frank and complete discussions of any flight problem.

B. All problems presented at Level III or IV cannot be brought to the Level I FRR. However, certainly all problems associated with Criticality 1 hardware should be required to be discussed in detail.

Question 8. There are approximately 700 to 800 components on the Space Shuttle Critical Items List.

A. What is your assessment of the efficiency and accuracy of this system of monitoring critical items?

B. What improvements, if any, should be considered for this system?

Answer 8 (A and B). The Commission has called for a NASA and contractor review of all Criticality 1, 1R, 2, and 2R items on the Critical Items List and for an audit of this review by an independent National Research Council panel. The review would serve to recertify all of the most critical items on the list and to determine what changes should be made prior to the next launch. In addition, the review ideally will facilitate a reassessment of procedures concerning the resolution and reporting of problems involving items on the Critical Items List. In addition, the Commission did specifically call for more rigorous maintenance procedures for items on the Critical Items List.

Question 9. The Commission has recommended that NASA should give additional and considerable attention to its Safety, Reliability, and Quality Assurance program.

A. During the investigation, did you ever learn why this program, over time, decreased in importance?

B. Could you compare the present program of Safety, Reliability, and Quality Assurance to that which existed in the Apollo program?

Answer 9. A. There was a lack of concern and attention by key managers from the Chief Engineer to the Center Directors, to Project managers. In a limited employment environment with mandated ceilings, managers put emphasis on "production" workers (engineers, managers, and operators), rather than SR&QA employees. The perception of an "operational" program also wrongly led to further reductions in importance.

B. Today, the SR&QA program has less people, less voice, and less impact than during Apollo. Also, the personnel appear to have less status in the eyes of key managers. In April 1974, a Space Shuttle Crew Safety Panel was established to identify possible hazards to Shuttle crews and to provide guidance and advice to Shuttle management. This panel ceased to exist as an independent forum when its original chairman retired in 1981.

Question 10. It appears that NASA's Safety, Reliability, and Quality Assurance program was deemphasized, beginning in 1983, when Level III was no longer re-

quired to report up to Level II about flight safety problems, flight schedule problems, and problem trends.

A. In your investigation, was this change in reporting requirement ever expressed as concern by NASA personnel?

Answer 10. Quite to the contrary, both Level II and Level III personnel were satisfied with the revision. the current Level II personnel were not aware of the history of the change. It should be noted that there is still a formal requirement in the Problem Reporting and Corrective Action document to report any launch constraints to Level II.

Question 11. You cited that NASA's flight rate goal was placing undue stress on NASA's resources and manpower.

A. In your opinion, was there any recognition by any of NASA's management—in headquarters or at the Centers—that safety could have been compromised by the pressures of the flight schedule and its effect on the work force?

Answer 11. There clearly was concern that pressure might compromise safety, but testimony indicates that all levels of management had convinced themselves that flight safety was not being compromised. The Astronaut Office did document a number of flight safety concerns in internal memoranda.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1. The Commission has concluded that the SRB joint test and certification program was inadequate.

A. What is the Commission's assessment as to why such an inadequate program was established and tolerated?

B. Who was responsible for these tests—NASA, Norton Thiokol, or both?

Answer 1. A. The Commission believes that adequate testing was not conducted due in part to an erroneous assumption that the similarity between the SRB joint seals and the Titan joint seals allowed reliance on the prior flight history of the Titan to establish confidence in the SRB joints. The costs of more thorough testing was also a likely consideration. Reliance on similarity to the Titan design proved to be faulty reasoning since there were differences between the designs and since there was no way of knowing what thermal distress the O-rings in the Titan joints may have experienced because the Titan hardware was not recoverable. Additional testing was not called for after seal problems arose apparently because of cost and schedule concerns and an unwarranted reliance on analysis.

B. Both NASA and Morton Thiokol were responsible for conducting, reporting, and interpreting the SRB joint testing and certification program.

Question 2. How did this SRB joint, with its obvious flaws and with the concerns raised about it in its initial design and development, evolve into an operational system—were there not check-points along the way that should have guaranteed the development of a safe and reliable joint?

Answer 2. There is a basis of arguing that a redesign effort should have been initiated when static tests as early as September 1977 showed evidence that the joint design did not work as intended. The early flight incidence of O-ring erosion on STS-2 in November 1981 during the "developmental" phase should have been sufficient to cause corrective action to be taken. The request in December 1982 for a waiver of the requirement for the secondary O-ring to provide redundancy to the primary O-ring should have precipitated a more extensive reassessment, especially when flight experience indicated that the primary O-ring could suffer damage. The increased frequency of flight problems should have been sufficient warning. Finally, the August 1985 briefing to Headquarters of the history of O-ring problems was sufficient to have required corrective action. More attentive management review and a more vigorous Safety, Reliability and Quality Assurance role could have provided the ovesight needed to assure the development of a safe and reliable joint.

Question 3. Your report discusses the effect that cold temperature may have on O-ring resiliency and on the stability of the O-ring to seal the gap between the two motor segments.

A. What tests had NASA run in the past to establish the minimum temperature at which the O-rings would reliably perform?

Answer 3. NASA and Thiokol has reports on cold-gas subscale O-ring test conducted at temperatures as low as 30° F., and had experience with a Development Motors tested at 40° F. with no apparent detrimental effect. Morton Thiokol engineers testified that these tests were not representative in that they did not simulate launch processing procedures or the in-flight configuration.

Also, resiliency tests had been performed by Thiokol in 1985 for the purpose of quantifying the seal timing function of the seconday O-ring and the effect of joint rotation on the seal's redundancy. These tests demonstrated that the O-rings were not as resilient at cold temperatures (Report, p. 136–37, 140).

Question 4. When O-ring leak check pressures were increased over the course of the Shuttle flight program, there was an attendant increase in erosion of the field joint and nozzle O-rings.

A. Were you able to establish why these pressures were increased to begin with, and why no one noticed and acted on the cause-and-effect relationship of the increased pressure and increased O-ring erosion?

Answer 4. The leak check pressure were increased because NASA and Thiokol believed that during the leak check procedure the putty could "mask" a pressure leak from a defective O-ring or an improperly seated O-ring. The pressure was increased sufficiently to "blow through" the putty to ensure that the putty did not serve as an unintended pressure seal during the leak testing. However, this increased pressure caused more "blow holes" in the putty, allowing a direct hot gas path to the O-ring, thereby increasing the frequency of erosion of the O-rings.

No trend analysis relating to leak check pressure was performed by Marshall Safety, Reliability and Quality Assurance. Engineers and program officials did, at various times, express concern about the potential of "blow holes" causing O-ring erosion. However, no direct correlation of increased frequency of erosion with the increased leak check stabilization pressure was apparently made.

Question 5. You have concluded that humidity, temperature, and other variables in the putty compound could have been a factor in the initial joint failure.

A. What test did NASA conduct to ascertain how and to what extent these variables would affect joint performance.

B. What conclusions did you reach about the need for putty in the joint, at all?

Answer 5. A. From March through June of 1983, Thiokol performed several tests to the types of putty used, of the effects of leak check pressure on the putty, of the effect of SRB assembly on the putty, and of the effects of putty lay-up or application. Marshall specifically asked for more putty tests on December 6, 1983. Moreover, as a result of the NASA Action Item sent to Thiokol after the STS 41–C Flight Readiness Review (April 5, 1984), Thiokol planned some subsequent testing on leak check pressure, assembly loads, putty lay-up, and other variables. Some of these tests were performed during developmental motor firings in 1984–1985. However, a March 6, 1985, Marshall document reflected dissatisfaction with the rate at which Thiokol was completing the planned tests (Commission document PC 009909–PC 009911).

A fairly comprehensive review of the entire O-ring erosion problem, documenting putty type, putty lay-up, leak check procedures, and so forth, was recently completed by Brian Russell at Morton Thiokol (Commission document PC 038217–PC 038276).

B. The Commission agrees with the May 2, 1986, testimony of NASA witness James Kingsbury that the unpredictability of the putty's behavior makes it desirable that the new joint design should *not* contain putty.

Question 6. The Challenger had been on the pad for 38 days and had been subject to seven inches of rain before its launch. This situation obviously could have led to the formation of ice in the joints.

A. At the time of the Challenger launch, was there a NASA protocol for periodically assessing rain accumulation in the SRB joints, and if there was not, why was there not such a protocol?

B. If there was such a protocol, was it acted on?

Answer 6. No protocol existed. On STS–9 a requirement arose to remove the Orbiter from the launch pad. When the SRB was de-stacked, water was found in at least one joint. However, no problem report was written on this condition. Failure to alert managers of the potential for water in the joints contributed to the lack of a protocol. After the 51–L accident, a check of the SRB's for STS 61–G assembled on Pad A indicated that spaces the thickness of a credit card were evident at the joint and thus water accumulation was certainly possible.

Question 7. A. Could you explain the rationale for the waiver of the launch constraint that was imposed on flight 51–F in July 1985, and on all subsequent flights?

B. How did it occur that Morton Thiokol and Levels I and II at NASA were unaware of these particular launch constraints and waivers?

Answer 7. A. The rationale given by NASA witnesses was that they believed the cause of the serious erosion of the primary O-ring and the subsequent erosion of the secondary O-ring on the nozzle joint of STS 51–B (which led to the launch constraint prior to 51–F) was an improperly seated primary O-ring in the nozzle joint seal not

detected by the pre-launch leak check. They concluded that a recurrence of this problem could be avoided by increasing the leak check stabilization pressure from 100 psi to 200 psi. In retrospect, the Commission found that this rationale did not adequately justify the waiver of the launch constraint.

B. Even though a written requirement existed for Level III to report launch constraints to Level II, it was not done (Report pp. 138-39, 159). The Level III managers testified that they did not believe there was a requirement to report the existence of a launch constraint or its waiver.

Question 8. According to your report, a Marshall definition of launch constraint states that "all open problems coded Criticality 1, 1R, 2, and 2R will be considered launch constraints until resolved or sufficient rationale is given that this problem will not occur . . ."

A. Given that approximately 700 to 800 Criticality 1 items are presently under review by NASA, over 100 of which are related to the SRB, how many of these were treated as launch constraints, and how many of these launch constraints were being waived?

Answer 8. Launch constraints were defined as all open problems coded Criticality 1, 1R, and 2R. In other words, only flight anomalies or problems involving Criticality 1, 1R, 2, and 2R were constraints. If no problem occurred, obviously no constraint was established. The Commission did not attempt to determine the number of launch constraints that were waived during the program. In theory, the number of launch constraints attached to the SRB could be determined from the Marshall Problem Assessment System. However, the Commission found that the use and application of the Marshall Problem Assessment System, including launch constraints, was unclear and not adequately defined.

Question 9. A. What conclusions did you reach about NASA's Launch Commit Criteria system, particularly with regard to the SRB field joints?

B. Were these Launch Commit Criteria strict enough, and followed strictly enough to routinely ensure the safety of the Shuttle system?

Answer 9. A. There were no Launch Commit Criteria relating to the SRB field joints or to operational temperatures for the SRB other than the Mean Propellant Bulk Temperature.

B. The Commission was troubled by the absence of more specific Launch Commit Criteria relating to operating temperatures for the Shuttle system and its components.

Question 10. In December 1985, Morton Thiokol requested of Marshall that the O-ring erosion problem be removed, or closed, from Marshall's Problem Assessment System. According to your report, there was some confusion about the disposition of this request.

A. What were the ramifications of this confusion—did it affect the consideration of O-ring erosion as a problem at Flight Readiness Reviews?

Answer 10. The closure action had been requested by Marshall, completed by Thiokol, and accepted by Rockwell. The closure had been entered into the Marshall Problem Assessment System. However, Marshall SRB project managers testified that they were unaware that the system was showing the problem as closed and that the Program Office had not approved closure. SRM Project Manager Lawrence Wear testified that the erroneous closure entry meant that no "heads-up" was given (in the problem reporting system) prior to the 51-L Flight Readiness Review.

Question 11. It is my understanding that the Challenger encountered the most severe wind shear conditions of any Shuttle mission.

A. Was this wind shear detectable before launch, and if so, was it not considered to be too severe?

B. If NASA does not have a wind shear detection protocol, should it not employ one?

Answer 11 (A and B). The wind shears encountered by STS 51-L were typical of the worst winds encountered by a Shuttle mission. Prior to each launch, NASA uses weather ballons to measure winds, and this is routinely followed by a determination of acceptability. Previous launches have been delayed due to high altitude winds being outside the allowable operational envelope. However, for 51-L, both preflight and post-flight determinations indicate that the winds were acceptable and load limits were not exceeded.

Question 12. I understand that there were some discrepancies noted in surface temperatures recorded for the Shuttle and its launch facilities that may have resulted from imprecise temperature recording procedures.

A. Were these discrepancies significant enough to cause serious misjudgment in any launch decisions?

B. What changes should be considered to ensure the most accurate surface temperature readings?

Answer 12 (A and B). During the Ice Team inspection of the launch Pad B the morning of the launch (see Report, page 110), surface temperature measures of the Shuttle system and launch facility were taken with an optical infrared pyrometer. Of particular interest, the left had SRB was measured to be about 25 degrees Fahrenheit in the aft region, whereas the right hand SRB was measured to be about 8 degrees. These temperature measurements were not reported since there was no Launch Commit Criteria on surface temperature. After the Challenger accident, the pyrometer instrument was calibrated in accordance with the manufacturer's procedures. A correction of approximately +10° Fahrenheit to the prelaunch temperature measurements was calculated, implying that the aft region of the left SRB was about 35° F., while the right SRB was about 18° F. at the time of the measurements prior to launch.

Question 13. A. The Commission has recommended the establishment of an STS Safety Advisory Panel which would consist of NASA personnel and would report to the STS Program Manager. During the investigation when this idea was first broached at one of the Commission hearings, was it not envisioned, initially, as an independent panel, rather than one made up of NASA personnel?

B. What considerations led the Commission to recommend a panel comprised of NASA personnel?

Answer 13. When considering the need for a Shuttle safety panel, the Commission considered a number of options, including a completely independent body. The Commission ultimately concluded that the safety oversight and review role envisioned could best be fulfilled by those most familiar with the operational, program, and safety requirements of the Shuttle. It further concluded that the safety role was a day-in, day-out requirement. It determined, however, that this panel should be "independent" of program pressures: schedule, budget, management objectives. The Commission, therefore, recommended an STS Safety Advisory Panel to include members of the new Safety, Reliability, and Quality Assurance office, the Astronaut office, the Mission Operations directorate, as well as the program office. The panel will serve as an independent forum to raise safety concerns directly with the STS program manager.

Question 14. The Commission has identified tire, brake, and nosewheel steering systems as systems that must be improved. As you undoubtedly learned from your investigation, these problems have existed for some time.

A. What is the Commission's assessment of NASA's response to and treatment of these problems, prior to the Challenger accident?

Answer 14. Brakes and tires had received considerable attention and NASA can point to a number of tests and minor modifications. The Commission was concerned, however, with the experience of continuing damage to critical hardware, little or no operational margin, and repeated and frequent warnings by the Astronaut Office that the deficiencies be corrected as soon as possible. An improved carbon-carbon brake had been approved prior to the accident, but funding was still questionable at that time. These issues are obviously being addressed with more vigor after the accident.

Question 15. In your opinion, what other potentially hazardous problems exist in the Shuttle program, of a hardward, management, or organizational nature?

Answer 15. The Shuttle Main Engines, the 17-inch disconnect valves between the Orbiter and the External Tank, and the indicators for the vent valves for liquid hydrogen and liquid oxygen were other hardware concerns raised by the Commission. (See Chapter IX, Other Safety Considerations).

As mentioned in the Report, the Payload Safety program does not provide for NASA to conduct a detailed audit of compliance with safety directives. Compliance is certified by the payload owner/builder. Areas of non-compliance are frequently found very late and are often determined to be "acceptable" even if in direct violation of stated requirements. All of this to "keep the program moving" since there is often no time to make the payload as safe as the requirements say they should be.

Other concerns are raised in Chapter VII, the Silent Safety Programs, and Chapter VIII, Pressures on the System.

Question 16. Are there still any questions that are lingering in the minds of the Commission?

Answer 16. There are no lingering questions as to the cause of the Challenger mission 51-L accident. The determination of the cause of the accident was the primary charge of the Commission.

Question 17. It has been widely reported that Dr. Feynman has a dissenting, or differing opinion that will be included as an appendix to the report.

A. What is the nature of his disagreement with the report?

Answer 17. Dr. Feynman has no dissenting opinion. It was agreed during the early stages of preparing the Commission report that an independent analysis done by Dr. Feynman of the Shuttle's reliability would be included in the Appendix, not in the main body of the Report. This was agreed to by all, including Dr. Feynman, since the analysis was not a Commission product and did not relate to the Challenger 51-L accident.

Question 18. The Commission has concluded that the Shuttle's inadequate spare parts inventory has caused NASA to resort to cannibalization of parts from one orbiter to another, a practice that is "costly, disruptive, and introduces opportunities for component damage."

A. As you probably know, NASA is in the middle of a $450 million program to enhance its spare parts inventory. While this effort may not have been of any assistance to the current problems, what was the Commission's assessment of the adequacy of this program?

Answer 18. The Commission did not construe its charter to require an assessment of any ongoing or planned program for Shuttle support, or of the budgetary requirements for such programs. Hence, no assessment of the spare parts program was made.

QUESTIONS OF SENATOR PRESSLER AND THE ANSWERS

Question 1. The Commission recommends that NASA establish a Safety Advisory Panel to ensure that safety issues are brought to the attention of the highest levels of Shuttle management.

Specifically, how will this Panel ensure that staff level concerns about the integrity of any Shuttle component or system will be communicated to those ultimately responsible for crew safety?

Answer 1. The Commission recommended establishing an STS Safety Advisory Panel with its membership including representatives from the new Office of Safety, Reliability and Quality Assurance, the Astronaut Office, and the Mission Operations Directorate. It is intended that this Panel serve as an independent forum at which safety concerns from all staff levels can be raised directly with the STS Program Manager.

Question 2. What do you feel is the appropriate role of Congress in the reorganization of NASA, the redesign of the solid rocket booster, and the implementation of the Commission's other safety and organizational recommendations?

Answer 2. The Commission has indicated that it fully supports and recognizes the right and responsibility of Congress to exercise its oversight role as NASA determines how to implement the Commission recommendations and how to restore the U.S. space launch capability. The Commission, however, did not believe that it was appropriate for it to recommend to Congress how to carry out this oversight function.

Question 3. One of your recommendations stated, "reliance on a single launch capability should be avoided in the future." I think most of the country would agree with that assessment, especially in light of the series of launch failures that occurred after the Challenger accident.

Do you have any specific recommendations on the number or type of unmanned systems the United States should develop? Do you feel that a fourth Orbiter should be built?

Answer 3. The Commission did recommend that reliance on a single launch capability such as the Shuttle should be avoided in the future. However, the Commission did not believe it was within its mandate to make recommendations on the exact mix recommendation regarding building a fourth orbiter.

Question 4. According to your Report, NASA's top management was briefed on the history of the O-ring failures at a meeting on August 19, 1985.

How do you account for the fact that following that briefing no attempt was made to halt Shuttle flights until this serious problem was corrected?

Answer 4. The Commission has no explanation for lack of sufficient steps being taken by top NASA management after the August 19, 1985, briefing requested by NASA Headquarters (Level I). The Commission concluded that the briefing was sufficiently detailed to have required corrective actions to have been taken prior to the next launch. The briefing, however, did conclude with the recommendation "that it is safe to continue flying" based on analysis of existing data (Report, page 139).

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Question 5. The Administrator of NASA has said they hope to be able to launch again by July 1987. Do you think this is feasible assuming the recommendations of your Report are carried out in full?

Answer 5. NASA has recently indicated in its report to the President on implementing the Commission recommendations that the SRB design efort will take longer than anticipated, with the final Design Certification Review (DCR) planned for December 1987. The first Shuttle flight will consequently be after the beginning of calendar year 1988.

ROGERS COMMISSION REPORT

TUESDAY, JUNE 17, 1986

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

The subcommittee met, pursuant to notice, at 9:35 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space with the Administrator of NASA and many of the members of his senior staff.

Dr. Fletcher, we are delighted to have you here. As you know, just over a week has elaped since the time of the issuance of the Rogers Commission report. It has received both wide publicity and wide praise and acceptance.

From your perspective, by far from the least important of the elements of that acceptance is that of the President, his discussion with you late last week and his set of instructions to you with respect to that report. I may say that I too found the work of the Rogers Commission to be exceptional in its thoroughness as well as in the wisdom of its recommendations.

And we will want to hear from you today on how it is you propose to go about implementing the Rogers Commission recommendations and where, if anywhere, you may disagree with elements of those recommendations.

You obviously have taken on a very tough challenge, as has Admiral Truly. It is my opinion that both of you have acted in exemplary fashion to this point in dealing with what clearly is the gravest challenge to NASA, to its mission, and to its public acceptance.

We are all well aware of the fact that NASA has moved from a favored agency in the press to one which much of the press is enjoying kicking around at this point. Many people have enjoyed second guessing what you have done and where it is that you're going to go.

Our goal, however, as yours is, is simply to see to it that we correct the physical and human deficiencies which have been discovered in the light of the *Challenger* disaster, and to get NASA back to its primary mission as promptly, effectively, and as safely as we possibly can.

I am confident in your ability and that of the people who work for you to reach those goals. But it is obvious that there will be and that there should be more congressional and administrative oversight connected with the way in which NASA carries out its mission.

We have a particular and a peculiar need for your help and assistance, of course, and that need arises out of the fact that we must write an authorization bill for NASA as promptly as possible. We should have written it already, and more explicit guidance than we have received so far on the impact, the cost impact and the directional impact of the disaster and its aftermath, is something which the subcommittee urgently needs, and we hope that you will begin to provide guidance for us in that connection this morning.

Senator RIEGLE.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

Let me welcome all of our panelists today, and we've got a lot of work ahead of us, as we all well know. I am hopeful that today you will be able to shed some light on what the policy thinking is within the executive branch of government.

We have been getting very mixed signals, as you know, and we insofar as I know still don't have any specific recommendation, unless of course one has been hammered out last night and you're bringing it with you this morning. If you are, that would be good news indeed. I gather that that still is not where we are, that the policy process has not been completed.

So we are not going to get a firm recommendation, presumably, today with respect to the shuttle replacement or, for that matter, other very important related issues. I must say I am very disturbed about the fact that time is running on us here and we are very late in the legislative year. It is the middle of June.

We have got a number of other complex issues before the Senate, including wrapping up the tax bill and appropriation bills in most of the areas and the trade bill and so forth. So that time is getting away from us. And I see NASA in a sense in jeopardy of being caught in the backwash of those other events and perhaps not being able to see definitive action taken here that will need to be taken before the year is out.

I am distressed about that. I have made some suggestions as a way, some organizational arrangements that I think might help us on an ad hoc basis between now and the end of the year.

And I have mentioned that to you, Dr. Fletcher, and to you, Admiral Truly. And I may touch on that a little bit later. But I am concerned that we are falling further behind.

There is a story in the last couple of days about the problems we face with the Soviets well ahead of us in terms of their space station and the number of hours now that they have been able to log with cosmonauts in space. And so it seems to me every day that we lose here is a very costly day to our country and to our future.

And so I would hope that somehow we can find a way to break this impasse and this kind of policy paralysis that seems to be af-

flicting us and make some decisions and then move ahead with those.

The second thing I want to mention at the outset is this, and before we get very far down the track I think we've got to nail this down. The Rogers Commission was in the other day and we reviewed with them the findings of the Commission, and I know the President has charged you, Dr. Fletcher, with apparently preparing recommendations over the next 30 days to carry out the Commission's recommendations.

But one area where I think the Commission, having generally done I think an exceptional job in a short period of time, the one area where I think they have fallen short is that we do not have a clear sense of where in the organization and what specific job positions the basic mistakes were made.

And I am concerned about that because I don't want those mistakes made again, and I think the scale of the mistakes was such that when people make them they forfeit their right to have the chance to make them again in this agency, and I feel very strongly about it.

And so one of the things that I am going to want to review with you today is the thing that the Commission more or less stepped around, and that is the question of who, in the decision process, failed to do what they should have done.

Now, the Commission, when we asked them about that, indicated that in effect that was going to be left to you folks, and what I do not want to hear now from you is a response to the effect of, well, that is really the Commission's job. I do not want this thing passed back and forth.

They have passed it to you apparently, and so in order to assure ourselves and to assure the country that those mistakes are not going to be made again, at least by those individuals, I think we have to have some clear sense as to what is going to be done about it.

And we have been very patient, I think, in waiting for the process to move forward, the Commission to finish its work, and so forth. But I think we are now at the point where that part of the system that did not work, namely, the managerial system, and the individuals that did not function properly, did not report properly, were, I think, clearly involved in misjudgment of a scale that is unacceptable. I think we have to have some clear sense from you as to what the corrective steps are that are going to be taken.

And I think, finally, we owe that to several people. We certainly owe it to the astronauts that were lost and those that are still in the program. I think we owe it to the families involved. I think we owe it to all the other people in NASA who follow the rules and who do report as properly they should.

And I do not think there should be any kind of a general sense around that when people do not function properly that somehow that is an acceptable situation and by inference that that is somehow the standard operation within NASA. Clearly it is not. It cannot be, should not be. And I do not want people who carry out their jobs in a sense properly having their reputations tarnished by those who do not.

So for those reasons and for the assurance that I think the American people have to have, that in the future we are going to have the right people in the right slots, we have to be, I think, forthcoming on that count. It has been a long time since the accident happened and so I would mention that to you at the outset, because when my opportunity comes, if you have not addressed it in your own comments, then I will ask you to do so.

Thank you, Mr. Chairman.

Senator GORTON. Senator GORE.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you, Mr. Chairman.

The importance of today's hearings and the issue of resolving the problems associated with the *Challenger* tragedy cannot be overemphasized. The Associated Press this morning is carrying a story about the new edition of Jane's Space Flight, which says that the Soviet Union has taken an almost frightening, to use their words, 10-year lead over the United States and our space program.

The reasons cited by the editor of Jane's are that NASA made no contingency plans for the space program in case of an accident with the shuttle, and the Soviets are so far ahead of the Americans as a result that, in quoting Jane's, they are almost out of sight.

We have to establish long-term goals and objectives for a space program that will help us with an organizing focus to correct problems like those that occurred with the *Challenger* and those that put us in second place in space, if in fact that is the case.

I, too, look forward to exploring the questions which are still in need of exploration as a result of the excellent report from the Rogers Commission. I look forward to exploring your plan for implementing their recommendations, as the President has now ordered.

And I look forward to exploring your views, Dr. Fletcher, on some of the difficult decisions that this subcommittee has to make on the fourth orbiter, where the funding is going to come from, what we do about the space station, and some other questions that are still unresolved. And I look forward to having that dialog.

Thank you, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. I have no opening statement, Mr. Chairman.

Senator GORTON. Senator HOLLINGS.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Dr. Fletcher, you probably can note the frustration. Obviously, it is not with you. It is with my own committee up here, because I did not expect you. I expected the witnesses that are appearing over on the House side.

I thought we had an understanding, and we will have to pursue and clear up that understanding. But we were ready some time ago, around 2 or 3 months, to get going on an authorization. We did not have the information. But quite bluntly, Senator Riegle and I were using the holdup on the authorization to try to get some

agreement to look into the shuttle disaster itself and calling the witnesses and doing as the Senate did during the Apollo disaster.

Now, we are not doing that and we are moving forward, and I get somewhat the feeling that we're going to get a symbolic authorization bill that does not necessarily have the support or the feel of the Congress or the committee, that we just got an authorization bill; we do not know why or how or where we are headed.

That brings us to you and to your group here this morning. Specifically, I take it now that we, having conversed with you and others, are going to put the emphasis on research and development, instead of commercial launches and the commercial nature of the program. That means that we will launch only on the basis of safety and not on the basis of profit and loss or keeping up a commercial, competitive level of program with Ariane or anything else. There are reports we are 10 years behind the Soviets and the emphasis should be trying to catch up in R&D, not trying to compete commercially with the French.

I am trying to catch up research and developmentwise and spacewise and scientificwise with the Soviets. That would put us to a real thorough shuttle-type program in the sense of safety. In other words, we will reverse the policy.

We have not heard from you, but obviously we are going to have to go to the expendable launch vehicles, go where Defense was. NASA was over here and said everything is up in the shuttle.

Defense was over on the other side of the spectrum saying, no, put it up on the ELV's. And I think not that one has won or lost on that particular argument, but we will have to tend more toward the expendable launch vehicles rather than the shuttle for a good while.

I differ with some of the findings and I think some of them, frankly, have been covered up in the Rogers Commission, and I would like to get into that in depth. But that is not before you. You were not there and responsible at the time.

But one recommendation, of course, for example, that the Rogers Commission makes is to try to change around the inherent safety charge upon each and every element of NASA and the space program and the operation itself. Everybody was in charge of safety, and I do not agree that since everybody is in charge of safety, no one is. On the contrary, everyone is, and they check through to make sure.

What really happened in this sense I think is a breakdown in communications, and I would direct my questions to that, given the opportunity here at questioning time to find out why that breakdown in communications, or did we just drift toward giving total authority to Marshall.

I have got a bank operation in my own home State. It started in my town, but then as the operation grew and became statewide necessarily the headquarters moved from the coast where I live up to the center of the State, in the State's capital.

But the State capital bank operatives and chief managers were told, just leave that Charleston crowd alone, they run it, they know what they are doing; just sort of an unwritten rule that they were running things down in Charleston.

I find a similar pattern in the NASA, that Huntsville center thinks they are way more important and bigger and more knowledgeable than you folks here at NASA headquarters here in Washington, and you just leave us alone; we have got the shuttle, we have got the booster, we know what we are doing; and whenever you call on us, the order is go.

In fact, there is testimony to the effect—and it will have to be brought out sooner or later, or perhaps by the House side—that that was the Lucas policy, that you never refused a launch. Every time you were asked, the answer was yes.

And so I think there are some mistakes down there that would go to you in getting us a program to make certain that NASA and you as the principal officer in charge were on top of it, and not just on the spurt of everything going again, that we do not just clean up that cancer down there at the Marshall Space Center.

It is a cancer in my opinion. It has been a bad one, and if I had to fix the responsibility I would fix it on Lucas. I think maybe Mulloy is a fall guy.

Chairman Rogers thinks I am off on a bent to prove that the White House ordered the launch. I am trying to prove that the White House did not order the launch. He cannot get it through his head. He does not question a single witness from the White House concerning calls to the Kennedy Space Center on January 26 and a couple of days ahead of that. But he does not call a single one of those to remove any kind of suspicion or doubts there.

But if I had to fix it, I do not have to prove a case, as Chairman Rogers says, that they did do it, so he can apologize. I want him to apologize now for not asking and going over there and getting a single witness and just get their statements. That is all they had to do.

But it seems to me that is another problem that this committee ought to get into. We are 10 years behind the Soviets, there is no question about that. I want to hear from you on that, on Don Regan's approach to it, since we are caught up here in a 2-year lapse or 1½ years or whatever it is, do we use that time loss to our advantage and jump forward technologically in something even better than that shuttle?

These are the kinds of things now that the committee ought to really reflect on, and we want to hear from you about.

Thank you.

Senator GORTON. Dr. Fletcher, we would be happy to hear from you now. I understand you have a statement and Admiral Truly.

Dr. FLETCHER. That is correct, Mr. Chairman.

Senator GORTON. Excuse me.

Senator Ford, I am sorry, I did not see you come in. Do you have an opening statement?

Senator FORD. I am just here to listen.

Senator GORTON. Dr. Fletcher.

STATEMENT OF HON. JAMES C. FLETCHER, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY REAR ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; ARNOLD D. ALRDICH, PROGRAM MANAGER, NATIONAL SPACE TRANSPORTATION SYSTEMS PROGRAM OFFICE; JAMES R. THOMPSON, VICE CHAIRMAN, SPACE TRANSPORTATION SYSTEM 51-L DATA AND DESIGN ANALYSIS TASK FORCE; THOMAS J. LEE, LEADER, DEVELOPMENT AND PRODUCTION TEAM, DATA AND DESIGN ANALYSIS TASK FORCE; JOHN W. THOMAS, DEPUTY, ACCIDENT ANALYSIS TEAM, DATA AND DESIGN ANALYSIS TASK FORCE; AND CAPT. ROBERT CRIPPEN, ASTRONAUTS' OFFICE

Dr. FLETCHER. Mr. Chairman, members of the subcommittee, just a week ago, as you mentioned, the Rogers Commission issued its thoughtful and thorough report to the President and to the American people. We at NASA have spent a good deal of time since then studying the report and its recommendations. Last Friday, as you mentioned, the President himself noted the procedural and organizational changes suggested in the report will be essential to resume effective and efficient space transportation system operations and will be crucial in restoring the U.S. space launch activities to full operational status.

I want to assure you, as I did the President, that we understand our present responsibility. We will move with determination, without hesitation, to guarantee that the space program returns to the highest levels of excellence and accomplishments and impressive achievements. We will do what the President gave us his support to do, "make our programs safe, reliable, and a source of pride to our Nation and of benefit to all mankind."

With me today are Adm. Richard Truly, Arney Aldrich, Mr. Jack Lee, who is Deputy Director at the Marshall Space Flight Center, and who participated in the recovery operations, and Mr. J.R. Thompson, who was also involved in the recovery operations, on loan from Princeton University. These officials have had the responsibility for the cleanup or recovery of the accident. Later they will give you a firsthand report on our progress in implementing the Rogers Commission report recommendations.

But I wish to begin today by responding to the one recommendation which is not among Admiral Truly's direct responsibilities. The Rogers Commission recommended that NASA should establish an Office of Safety, Reliability, and Quality Assurance. It said that it should be independent of other NASA functional and program responsibilities. It also recommended that this new office have direct authority over safety, reliability, and quality assurance, and that it should report directly to me.

All of those suggestions will soon be realities. I am in the process of creating such an office, and will announce in the near future the person who will administer that new and crucial office. While every step of improvement is important, I believe this one could be the lynchpin that ensures that all the rest are working properly.

As you know, the Commission also recommended that we review the shuttle management structure. Admiral Truly announced last week that Capt. Robert Crippen of the Astronauts' Office would

lead a group to define the specific actions that should be taken to correct the deficiencies found in management, and I think Captain Crippen is here also this morning.

I have also had a panel under the direction of Gen. Sam Phillips, who as you remember was the Apollo program manager, already at work on a broader study of management systems and techniques, including the relations between our various space centers, with each other and with NASA headquarters. I am confident that the activity underway under Admiral Truly, Captain Crippen, and General Phillips among others will permit, indeed, will guarantee that we will meet the deadline set by the President last Friday.

He said:

> Specifically I would like NASA to report back to me in 30 days on how and when the Commission's recommendations will be implemented. This report should include milestones by which progress in the implementation process can be measured.

I have been asked to come back into NASA at this troubled time to meet the President's demands and to satisfy congressional concerns that we are once again working in a fashion that will resurrect both success and safety and will make America proud again. I will settle for nothing less.

Last week 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 decisionmaking, were poor, they would be made better. I repeat. I will settle for nothing less.

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 own decisionmaking. Part of this was the responsibility of a task force under Admiral Truly's general direction and with day to day direction by his associate, Mr. J.R. Thompson on my left. It involved the 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 activities were aimed at helping the Rogers Commission. The NASA task force reports were made to the Commission in mid-April, but data is still being gathered, analyzed, and pursued by appropriate NASA leaders. While the Rogers Commission has completed its activities, we have not. We search for the facts as we continue our work. The period from the *Challenger* accident to 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 few days, the questions of when we will fly the next 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 manufacture. You will hear more about all of that from Admiral Truly and his associates. 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. 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 a willingness to change. That is particularly so with this report. It was done thoroughly and with care, and 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 subcommittee and the Congress 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 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 in the future of the United States. Changes have already been made or will come, yet, Mr. Rogers said, "You do not want to punish, you just want to make sure it does not happen again."

I am reminded also of a statement by President John F. Kennedy, who said at another difficult time in our history, "Our responsibility is not to fix the blame for the past, but to fix the course for the future." This is the goal I think we all share. It certainly is the best, possibly the only way to reassert American leadership in space. The President said last week, "The men and women of NASA and the task they so ably perform are essential to the Nation if we are to retain our leadership in the pursuit of technological and scientific progress." That is certainly NASA's goal, beyond question. As I have said, speaking for the employees of an agency that has given lasting knowledge to the world and inspiration to this great Nation that we have reached with this Rogers Commission report, a day of resolve, a time of beginning, a time of redirection.

I hope my testimony and what Admiral Truly will tell you in greater detail demonstrates the validity of that assertion. When he is done, we would be pleased to respond to any questions you may have.

Thank you, Mr. Chairman.

Senator GORTON. Thank you, Dr. Fletcher.

Admiral Truly.

Admiral TRULY. Thank you, Mr. Chairman and distinguished members. With your permission, I would like to submit my statement for the record and summarize it.

Senator GORTON. It will be included, and we will be happy to hear the summary.

Admiral TRULY. Mr. Chairman, in the months since I returned to duty following the loss of the *Challenger*, I along with my entire organization have spent many hours in support of the Rogers Commission. I have done my best to assist them in the conduct of their investigation. I have read their report carefully, and I am having people that are pulling it together, not only just the recommendations and the findings, but the text, with a fine tooth comb to find those suggestions that we can, should, and will implement.

The report is extremely thorough and comprehensive, and I am in agreement with the findings and recommendations. I am extremely pleased to say that in my own case there were very few surprises in their findings and recommendations, and I attribute this to the closeness with which we worked with the Commission. As a matter of fact, I am pleased to tell you that we are well on our way in each of them, I believe, to being able to report to the President within 30 days as to our progress, and to also craft a format where as the months go on we can report efficiently to the Congress and to the President and to the people as we return to safe flight.

With your permission I would like to very briefly go through the recommendations one by one and summarize what has been done and where we are. The first recommendation had to do with the redesign of the joint of the solid rocket motor. Back on March 24, I directed that a redesign team be formed located at the Marshall Space Flight Center to include participation not only from Marshall but also from other centers, Johnson, Kennedy, Langley, from industry, and the leader of that team is with us here today, Mr. John Thomas. I am sure that if there are details that only he can answer, he would be pleased to step forward to the table and help us.

At that time an expert advisory panel was formed as an adjunct to the team. It includes about a dozen people from various locations, including about half from industry, and recently as a result of an early suggestion in conversations with the Commission, an oversight group from the National Research Council has been announced. We are having our first meeting with this oversight committee starting on Thursday and Friday of this week, and I welcome them and look forward to working with them as they help us as we make the decisions that are required to fix the problem and get back to flight.

Safety will be the primary concern, and the criteria for picking a redesign and the testing of that design will be the proof of the pudding. I think we are quite far along, but we have a very long way to go, and we will be pleased to tell you about that today.

The second major recommendation had to do with the shuttle management structure, and back on March 24, of the various things that I set in motion through the system, I took that action for myself and purposely did not take action on it until after the Commission had made its report. As Dr. Fletcher said last week, I announced that Capt. Bob Crippen, who has been a part of the investigation from the beginning, is going to be working full time to lead a small group of people that will reexamine our entire pro-

gram management structure within the space transportation system. I welcome Captain Crippen, as he will assist me and with options that we will be looking at in the immediate future.

His review will be done in coordination with Gen. Sam Phillips' review for Dr. Fletcher of the entire NASA organization and the way that we manage our programs.

The third major recommendation was a complete review of the critical items list and the hazard analysis, and again on March 24, I directed Mr. Arnie Aldrich, to my right here, who is the program manager of the space transportation system, to institute and formalize a very large review of every item on the critical items list. Not just the solid rocket motor, but the orbiter, the external tank, and the main engines. That is in work, and we will be pleased to answer your questions as to its status today. Dr. Fletcher has already addressed the next recommendation, which had to do with safety organization within NASA and the appointment of an office in NASA that would have safety, reliability, and quality assurance as its only and sole function.

The next recommendation had to do with improved communications within our system, and I personally think this may be the most important part of the Commission's work. It does not apply only to the Marshall Space Flight Center or to headquarters, but to all of our people and all of our organizations. Captain Crippen will also be taking a critical look at this recommendation as he will the program management structure, since they are so closely interlinked. One of the issues that came up, not as a direct result of this accident, but was looked at thoroughly by the Commission, was the subject of landing safety. That is the use of the Kennedy Space Center for landings, the status of our landing gear systems, our nose wheel steering, and our brakes.

We have known about these problems for some time, and we have already begun to take programmatic actions to get fixes in work and to continue testing that is in work, and we can tell you about that today. Another issue that quite naturally is and has been on the minds of the Commission and the public has to do with launch abort and crew escape. We have initiated a thorough crew egress and escape review of the systems aboard the shuttle. That review has been in work at the Johnson Space Center for some time. It will be some time before it is completed. We do expect in the next couple of weeks to have an interim report, but we can give you a status today, and as we go forward on that we will be pleased to communicate that with you.

One of the primary things that was recognized from the start and addressed directly in the report are the pressures on the system, some of which are caused by striving for a flight rate that may be overambitious. We are actively looking at the flight rate. I have already done that and reported to this subcommittee about our preliminary look at it, but I can assure you that when our final studies are done, that we will be projecting and flying at a safe and sustainable flight rate, and it is one that our system, our people, our spares, our logistics, and our program management can and will support.

The final and last recommendation had to do with maintenance safeguards, and we have already instituted or started to institute

changes in the sort of maintenance program that we anticipate after we get flying again, and we will be pleased to share that with you today.

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 that 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 for the opportunity to testify before your subcommittee today, for NASA needs your support and guidance as our Nation returns to safe space flight.

Senator GORTON. Dr. Fletcher, Admiral Truly, thank you. Does that finish your formal presentation?

Mr. FLETCHER. Yes, Mr. Chairman.

SENATOR Gorton. For the members of the subcommittee and the other guests, we will have one round limited to 10 minutes so that everybody will be able to get in, and then a second round, and each member can ask as many questions as he wishes on the second round. So 10 minutes for now.

Admiral Truly, one of the recommendations of the Rogers Commission was a firm payload assignment policy that would include rigorous controls on cargo manifest changes to limit the pressures such changes exert on schedule and crew changes. NASA's tradition has been to use a certain amount of flexibility in rearranging its cargo in order to accommodate customers or to maximize shuttle capacity.

Is this a recommendation with which you have reservations, or do you feel that the Rogers Commission changes are appropriate?

Admiral TRULY. No; it is not a recommendation that I have reservations about. This is one that I can directly and personally affect since the manifesting responsibility is in my office in NASA headquarters. As we went through the investigation and in talking with the Commission I think the primary problem is in the field, primarly at the level II which is Mr. Aldrich's organization. They have the responsibility to do the advance planning for the flights and there are too many late changes, changes to the manifest and instances, where even though we have rigorous guidelines in place, that when you get within x number of months prior to a flight, you should not change a certain item. I intend to thoroughly review that. I agree with it. I do not think that is going to take away our flexibility. In the space business we have always had changes, and I do not anticipate that this will change, we will have to accommodate late changes.

For example, we had a case this past year where we had a satellite actually on the pad that had a problem. We were forced to roll back and change the manifest. We will have to have the capability within the system to do that, but I intend to take a look at our manifesting process and make sure that the changes that we put in are required, whether they be satellites or people or procedures or whatever.

Senator GORTON. Dr. Fletcher, I am sure Admiral Truly can comment if he wishes. Are there any of the recommendations either

overall or in detail about which you have serious reservations and/or conditions, or do you look on all of them as being both valid, important, and attainable?

Dr. FLETCHER. Mr. Chairman, Admiral Truly and I have discussed this at some length during the days since the Commission report was given to us, and one by one we have looked at those recommendations, and we have no difficulty with any of them.

Senator GORTON. Admiral Truly, there has been a very heavy emphasis and, of course, an appropriate emphasis on the solid rocket boosters as the cause of this accident over other Criticality 1 items. In your testimony, you told us about your immediate beginning with that problem. Can you outline at this point what kind of changes you are either going to make or are most likely to make in the redesign of the solid rocket boosters and their seals to prevent a future accident like the accident which destroyed the *Challenger*?

Admiral TRULY. We have not chosen a design so that I cannot describe to you what the redesign will be. We are looking at many options. We very much would like to have a redesign, and I am assuming we will have a redesign that can use the case hardware, the raw case hardware that is being delivered to us and was already under contract at the time. We are not limiting ourselves, however, to that possibility, and as a matter of fact, just this week, we had a meeting to look at other design possibilities in the event that the testing of our approved redesign when we have one fails along the way. This will save us months in the future.

Dr. FLETCHER. Mr. Chairman, could I add to that a little bit? Although that is in the area of Admiral Truly's expertise and his associates, I have had an opportunity to go over the designs, and although he may be modest about saying so, all of the designs that were shown to me are greatly superior to the one that was involved in the accident. No matter which one is chosen, I think they all look very good. But of course you will not know that until you have gone through the test program, and that is what Admiral Truly was emphasizing.

Senator GORTON. Do you intend to test several different designs before you decide on one?

Admiral TRULY. We are doing a lot of early subscale testing in order to determine a final design. What Dr. Fletcher has said is very important. As you know, the Commission found that the cause of this accident was a failure of the solid rocket motor joint. However, there are four or five areas within that that could be probable causes, so we are requiring that this redesign assume that each of those was the primary cause, and we will design it out in the future.

For example, the doubt on the use or the performance of the putty, the possibility of water getting into the joint and turning into ice, the possibility of damage during assembling an O-ring, and so forth. Each of those possible failures will be designed out of the new design, whatever it turns out to be.

Senator GORTON. Is this most likely to be the problem which governs when we fly again whether or not it can be July 1987 or at any time in 1987? It seems to me that your answers have been, first, you have got to pick a design, and then, second, you have to implement that design, test it, all of these, before we launch once

again. How does that fit, Dr. Fletcher, with that July 1987 goal, but with the overriding concern over safety, and is it likely to be the single factor which takes the longest?

Dr. FLETCHER. Well, Mr. Chairman I probably ought to answer first, but Admiral Truly, I am sure, will correct me if I get off track. Of course, there are many, many things involved in that launch which is now planned for summer of 1987. If I were making a judgment, I would say not just the choosing of a design, but the test program that is associated with whatever design or designs we go forward with probably will be the determining factor in whether we launch again.

Having said that, however, until you actually get into the redesign of these various critical items, which are also under review, you need to review things like management, which I am reasonably sure we can handle by then, and other possible constraints for launch. I should not mention this, but it is also conceivable that there might be funding constraints. If there are any, I will sing out, but right now there do not appear to be any. But these are all possible constraints on that launch date.

If I were guessing, though, I would say it is still the testing of those seal designs that would probably be the long pole in the tent.

Admiral Truly, do you want to correct what I just said?

Admiral TRULY. No; I agree with that. Of the items that we have seen so far, and the difficulty involved with full-scale testing of the redesigned solid rocket motor, taking that system through a preliminary design review and the critical design review, and then getting concurrence of the oversight committee, I see that as the long pole in the tent.

Senator GORTON. What about the unused solid rocket booster elements manufactured by Morton Thiokol that you have in storage? Are they, under most of your redesign efforts, going to be usable or are they going to be waste?

Admiral TRULY. There is some hardware we are not going to be able to use; however, we did have already in as a portion of the filament wound case development a design that involves a capture tang which will help us, but not completely, solve the problem that you are aware of in joint rotation; in other words, the movement of the joint caused by the pressure transient at ignition.

It is that hardware, and I should also say that after that capture tang had been designed into the filament wound case joints, we began to get the manufacturer of the raw case hardware to deliver to us hardware with enough metal so that it could be machined with that capture tang of various dimensions. It is that hardware that we intend to use.

Senator GORTON. One more question. What has the accident and your investigation and your work done with respect to your views on second sourcing?

Admiral TRULY. As you know, we have instituted an effort to go out and start a solid rocket motor second-source initiative. That was in the works, and after the accident, that effort was put on hold. I have the action within the Office of Space Flight to look at all the complex factors that we have now facing us and make a recommendation to Dr. Fletcher as to what I think is the proper way to go.

Frankly, with various factors of redesign which are still in the future, the Research Council Oversight Committee, which has not actually joined us in a working sense yet, that action is still in my in basket, and I have not reported to Dr. Fletcher what direction I believe we should take.

Dr. FLETCHER. Mr. Chairman, I want to make sure that it is clear that second source will not affect the start date when we fly again, that that will be downstream if and when it is implemented.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Mr. Chairman, before the clock clicks on in terms of my time with the witnesses, I am wondering if I could perhaps pose a question to you just in terms of subcommittee business which I think we ought to try to pin down at the outset.

Senator GORTON. Sure. Go ahead.

Senator RIEGLE. Senator Hollings has some concern, as he has indicated, and I share the concern that we make sure we have a recommendation in hand from the administration on the major space policy decision on the replacement of the shuttle, if that is to be recommended, how it is to be paid for, all the collateral policy issues that go with that, prior to the time that we undertake the markup, on the theory that if we do not really know where we are going, we cannot chart a proper course.

I am acutely conscious of the pressure of time, as I know you are, and so I have no desire for us to delay a single hour, because I think we are already very late. On the other hand, I do not know how we can properly go through a process of putting a recommendation to the Senate if we have not had a clear recommendation from the administration. That is my first point.

My second, and perhaps you could address both of them, is that I am concerned that this subcommittee has not yet arranged, in my view, to pursue some of the questions that remain from this accident. This is the appropriate subcommittee in the Senate.

The House, as I understand it, this week is calling witnesses which include Dr. Lucas and apparently Mr. Mulloy and others who were involved in the breakdown in the management system that led to the state of launch. It is appropriate that they do so. I am pleased that they are doing their work.

I do not, however, view that as a substitute for our work, and I am wondering if we will here shortly also be able to raise directly with key management people within NASA questions which many of us have that I think are as yet unanswered.

So we have not yet had a chance to discuss this because events are sort of rolling ahead on their own, but I think those are two very important questions, and I pose them in the spirit with which we have worked together all the way along here, with the Commission and with one another. I want to continue to have that kind of constructive approach to it, because that is what I think the problem requires.

I am just wondering if you could give me a sense of your thoughts on those two things.

Senator GORTON. I am happy to deal with those without those counting against your initial 10 minutes. I will take them in reverse order.

I must say that this chairman regards our oversight over the future of NASA and its getting back into flight as being much more important than going into the details of the past. Nonetheless, if you and Senator Hollings and other members of the subcommittee have specific concerns which we can productively address here, I think that we should meet together and find out what those concerns are and see whether or not we can deal with them effectively.

Now, as I say, my primary goal is to be engaged in the activity in which we are engaged here today and relating our work to the future. With respect to your first question, you know we have shared an intense frustration at the unwillingness or inability of the administration to get its act together and to make recommendations to us as to the future of NASA.

Senator Hollings, both you and I serve on the Senate Budget Committee Conference which in fact is meeting right now. We have, in that connection, not waited for the administration to get its act together. We have made a very specific offer on a budget resolution which involves NASA in hopes that making that recommendation, taking a Senate position, a bipartisan position, would force the administration into an answer.

As a consequence, it is my disposition not to wait much longer for administration recommendations in order to determine a committee and a subcommittee position. I believe that we should decide what we think is right and write an authorization bill on that basis, with the hope that it might trigger action on the part of the administration.

Now, I do not want to do that in a way which is going to be divisive in the committee or on the floor of the Senate, but most particularly in the subcommittee and the committee. If even a good percentage of the members do not want to do anything about an authorization until the administration comes forward with a recommendation, I suppose I will have to defer to that position.

My own view is, and I can express it here publicly as I would privately, that we have responsibilities in this regard just as the administration does. The fact that the administration does not live up to what you and I consider to be those responsibilities, in my opinion, is going to make our job harder, but I do not think we should abandon doing the job.

Senator RIEGLE. I thank the chairman for his response.

Let me take it just one step further. I know about a month ago, over a month ago, we asked Admiral Poindexter of the National Security Council if we might be able to have a discussion on space policy issues so that we could at least get a sense as to where they might be heading and use that usefully here in making our own judgments. We have had no response from that request.

I know they have been busy, but presumably there is a need at some point for some discussion. I suppose Senator Hollings would also like to reflect his thought on it as the ranking member of the full committee, but the point I want to make here is this: I think we are at an absolutely crucial point in the space program. In other words, we are now confronted with a host of enormous policy questions that we could not foresee a while ago prior to the accident, but the accident, together now with other things, brings us to

a point where we really have to work through and set a course for the Space Program for several years into the future.

The decision as to whether or not to have another shuttle; whether that is to come out of the hide of NASA in terms of its current programming or whether we face up to the fact that we may need money in order to decide if we are able to pay for a replacement shuttle; the whole question of whether we stay in the commercial launch business; of whether we are going to go in a major way to expendable launch vehicles; whether we stay on target with our space station timing and program, these are absolutely vital questions, I think, to the country and to our national security.

I am not suggesting that the chairman disagrees. I am just expressing my own view. I do not think we can kind of run on through those questions without everyone sitting down and talking with one another and coming out with a kind of a very solid national consensus.

So I am reluctant to, in a sense, steamroller the administration or to have them steamroll us because we are all headed in the same direction. I would hope that we would resolve the questions before we start spending money on making recommendations to the Senate.

I think when we go to the Senate floor as an authorizing committee and subcommittee, we have to be able to say to our colleagues in the Senate this is what we see as the future program for space for our country, and we have talked it through. The administration, ourselves, and hopefully the House as well, and NASA are together with a common plan which we have really worked through. We know where we are going, and we can now go to the American people and ask them to join in that commitment and to provide the money to see that it is done.

I am not sure that at a point as momentous as this that we can do it any other way properly, and so I am very uneasy about the notion of saying that because the administration is late, which they are, we will just roll ahead anyway. I think somehow with the discussions which have to take place with Don Regan and with yourself and Chairman Danforth or what have you, I think I would like to proceed in what I would consider to be a more orderly fashion, given the magnitude of the decisions which we have to make.

Also, of course, we have this closing legislative window. We have probably no more than 55 or 60 legislative days left this year, and I am concerned that we are going to get caught in the backwash of events and that we will just roll on into next year without these thing being clearly decided.

Senator GORTON. That is correct. If we do nothing, we will just find something in a continuing resolution or an appropriations bill in which the policy will be settled.

Senator HOLLINGS. I think there is no question, Mr. Chairman, that you and I and Senator Riegle and the committee members will move forward. I think we all believe in the shuttle and the Space Program. There is no question that we are 100 percent behind it. We are going even in the Budget Committee to get the other $7 billion or whatever it is. There will be enough money in there, and I

am willing to put the taxes and the revenues there to support this program.

That is where I go down a different road in the context of just trying to solve the administration's intramural problem. I think that, quite bluntly, Dr. Fletcher, quoting John F. Kennedy, and no one in this room could be closer to him than I, our responsibility is not to fix the blame for the past but fix the past for the future. Jack Kennedy would have said that without any shuttle disaster, without any capsule fire. Our responsibility is to fix the blame for the past in order to fix the course for the future.

I am not trying to put anybody in jail. After all I already have said there was no real malice in mind and we were not trying to kill astronauts and everything else, the silly Washington Post is trying to talk about criminal stuff. They are still bent on relegating Hollings into some kind of untenable, nonsensical position.

I am very genuine and sincere about this thing. Unless we can find out why they broke down in the communications and why they did not follow through the normal channels—you see, I found NASA, generally speaking until all of this came out, had very safe procedures.

Now, they have gone over all of these criticalities and everything else, but if I am looking as a lawyer at proximate cause, proximate cause is not, in this context as we in the law would know it, a flawed process but a violated one. I will ask Captain Crippen to join you all at the table, and just ask him. He can be thinking it over. I would like to know from him what happened, because I heard comments that he made at the particular time. That is all I am trying to find out.

You folks are trying to give the Rogers Commission the good government award. The heck with that. I am trying to get a Space Program that we all can proudly get behind, and we are not going to fashion one of those unless we get through with the Rogers Commission. They make, I think, a fundamental flaw in recommending a safety officer. Once you have the safety officer, nobody worries about safety because that is the safety officer's problem.

We know that that is the way it has worked whenever you set that thing up, and I do not want to go down that particular road. I want to reinstitute that procedure, for example, Captain Crippen, when you come up, whereby you said the process was always that NASA cross-examines the contractor as to why fly. In this case, it was why fly rather than why fly. I like that procedure. Here, by gosh, the contractor is saying why not to fly, and you all were saying let us go, forget about safety. Forget about safety, let us go.

As I understand what Captain Crippen said, to sort of refresh his memory he said that the process was reversed for the first time in his memory. Now, he can stand up and clear that up later on when I get my time.

Mr. Chairman, you know we are going to get a budget. We are going to put some money in, but we are not going to have a Space Program really going unless we get in and find out and just get some positive recommendations rather than the litany of taking the Rogers report. We are looking at this; we are looking at that; we are looking into the next thing and everything else. We are doing all of these things. That is fine business, but we do not have

a map for us, really, of how we intend to catch up in space and really get it going again from this particular group this morning.

Now, that is what I want, and that is what you want. Maybe they will have to come back after they have done some of this reflection. They have not lined it out, and maybe it has to begin with the administration. Obviously, it has to begin with the administration but then they will have to put it in, rather than with the Rogers report, with the administration submission. Then you and I have got to look at it and make sure that this whole thing gets back in harness where the House and Senate, Republicans and Democrats and everybody are fully behind the program.

I am confident the money is going to be there. I am confident you and I are going to put it in the budget, even if they never send anything up from the White House. Do you not agree?

Senator GORTON. Yes. I think we had better get back to the questions of this panel now.

Senator Riegle, now your time is starting.

Senator RIEGLE: Thank you, Mr. Chairman.

I am convinced that we are going to solve the mechanical problems that led to this disaster. In fact, there were very competent people within NASA who felt they knew what had caused the accident after the explosion and before the shuttle and the rockets had even hit the water because of the history of the O-rings and so forth. That has all been laid out in the Rogers Commission report.

I think that is the easiest set of problems to solve. Although they are very difficult problems, we will solve those problems. Those are the ones we know how to solve, and we will get them solved.

I must say I do not have at the moment yet the same degree of confidence with respect to how we are going to solve the internal management issues which are related to it. In this, I have great confidence in you, Dr. Fletcher. As you know, I was a supporter of your nomination because I felt that you were a person who could tackle that, and I have the same feeling about Admiral Truly.

I think that job is a lot tougher, and I think sometimes it is awfully hard to get the full truth. I think there has been a lot of evasion in terms of even assembling the truth. In the case of the work that the Rogers Commission has done in terms of what happened and who did what and so forth, a lot of the information that was gathered by the Rogers Commission grudgingly came very late.

That is very troubling to me, and it tells me that some of the problem that led to the breakdown in the management decision process I suspect continues to this day, and I want it tracked down and dealt with so that we can have confidence that it is not going to happen again, at least by those individuals.

So let me start with you, Mr. Aldrich, and I would like to ask you just some very direct questions. Did you know about the argument the night before the launch, anytime prior to the launch?

Mr. ALDRICH. No, sir, Senator Riegle, I did not know of the discussion or of the criticality of it.

Senator Riegle: Should you have known?

Mr. ALDRICH. Yes, sir, I should have known.

Senator Riegle: Who would normally have been responsible for giving you that information?

Mr. ALDRICH. Normally I should have received that information from the shuttle project's manager at Marshall, Mr. Reinartz, or from Larry Mulloy, the solid rocket booster project manager.

Senator Riegle: Under the existing system that was in place at that time, did they have an affirmative obligation to give that information to you?

Mr. ALDRICH. Yes, sir, I believe they did. In fact, in the meeting earlier in the day where we discussed all aspects of the temperature and the weather effects on the launch we specifically asked. We reviewed all of the technical and procedural issues that might be impacted by the weather, and we specifically asked for any other questions or concerns that might come up during the course of the remaining day or into the countdown to be brought forward. In fact, I believe that was a specific request for that sort of a report.

Senator Riegle: So you asked for it, or it was asked for but it was not provided, is that correct?

Mr. ALDRICH. It was not brought forward.

Senator Riegle: It should have been, I take it?

Mr. ALDRICH. My opinion is definitely that it should have been.

Senator Riegle: Is that a matter of NASA procedure and practice that is well established, that in a matter of that magnitude it would be expected and proper practice for that information to be related to you?

Mr. ALDRICH. Yes, sir.

Senator Riegle: So there was a breakdown at that point?

Mr. ALDRICH. I believe there was. I had strong confidence in our system as it should work, and I had no uncertainty that concerns would be brought forward. I think our system has documented procedures and provision for that to happen.

Senator Riegle: Now, with respect to the O-ring problem, its long history and the fact that last year, I believe in August, there was a meeting at the level I level of NASA where Michael Weeks participated where the O-ring problem was discussed in some detail, were you familiar with that meeting and the concerns that were raised at that time about that problem?

Mr. ALDRICH. No, sir, I was not. I was only informed of that meeting after the accident and in particular the level of personnel who were involved and the detailed technical content of that briefing. I did not know that such a deliberation was active in the program.

I might add that I took this job I am in in August. I was in another position, and I was not sensitized particularly to go seeking out such an activity with regard to the prior history.

It is my belief, though, that the proper way for information of that criticality to flow is through the level II office, which I am in, and it did not flow in that manner.

Senator Riegle: I do not know what the dates are of the overlap in August in terms of when that meeting occurred and when you came aboard, but it seems to me that presumably someone had an affirmative managerial obligation to see that you had that information. Am I correct in thinking that?

Mr. ALDRICH. I think most certainly that is correct, given the criticality of the subject and the amount of concern which now is

apparent that was out in the program at the different levels of the organization.

Senator Riegle: Who would have had the obligation to bring that information to your attention?

Mr. ALDRICH. I am not sure how the meeting was called, whether it was requested by NASA Headquarters Level I organization or in fact if it was brought forward by the Level III project organization at Marshall. I do not know who first said we should have such a meeting, but either of those levels should in fact have used the process of communication through the Level II office, Shuttle program management in Houston, as the mechanism to be sure that all parties and all communications were involved in the deliberations that followed.

Senator Riegle: In terms of the connecting points down that management structure, who would be the person that reports immediately to you from those lower levels? Who in a sense would be the person that normally would deliver that message had it been properly delivered to you?

Mr. ALDRICH. Well, normally the report coming up from the level III project would come from Mr. Reinartz and Mr. Mulloy to myself, indicating that a technical issue should be discussed and requesting to bring it forward.

If the request was in fact the result of deliberations at NASA Headquarters about concerns that related to the immediately prior flight which had a nozzle erosion question, then again the more correct way and the programmatically correct way to ask what that information would be for the NASA Headquarters organization to send me directions to set up such a meeting and to involve all parties.

Senator RIEGLE. It sounds to me like it was the same individuals again that would have had a managerial obligation under the normal course of events to bring this information to your attention, and did not do so.

Dr. FLETCHER. Mr. Chairman.

Senator RIEGLE. If I may, Dr. Fletcher, let me just nail down this answer, then I would be happy to hear from you.

Mr. ALDRICH. The program communication management channels are essentially the same from project to program to NASA Headquarters in the day-to-day business.

Senator RIEGLE. So these would be the same individuals? Is that what it boils down to?

Mr. ALDRICH. Yes, sir.

Senator RIEGLE. You wanted to say something, Dr. Fletcher?

Dr. FLETCHER. I wanted to make sure that information, Senator Riegle, has to flow both ways, and so I think it was also the responsibility of the headquarters people to inform Arnie Aldrich of the seriousness of the problem. I want to make sure that we do not have a one-way communication system.

Senator RIEGLE. I think that is a very important observation. Who would have been the management people at the higher level that would have had an awareness of this problem that might also have properly reported it to you?

Mr. ALDRICH. My reporting channel in the program was to Admiral Truly's predecessor, Mr. Jesse Moore. Mr. Weeks was his tech-

nical deputy in this area. Mr. Weeks was in fact, as you know, the man that conducted this technical forum.

Senator RIEGLE. So should Mr. Weeks likewise have reported this to you?

Mr. ALDRICH. There are a number of offices there, any one of which might have been the specific person or office, but the organization as a whole should have not reported it so much as requested that we be directly involved and specifically arrange it.

Senator RIEGLE. Going up the ladder, would Mr. Weeks or Mr. Moore be the critical point?

Mr. ALDRICH. It could be Mr. Moore or Mr. Weeks, and Mr. Moore did not have a deputy. His deputy position was vacant at that time. It could be his deputy.

Also, there is a Propulsion Office at NASA Headquarters under Mr. Winterhalter who frequently would pursue arrangements to be sure they were conducted in a complete fashion.

Senator RIEGLE. Is it your understanding that the O-ring problem knowledge was known at that higher level? It certainly was by Mr. Weeks, because he had participated in that briefing in August so he had the information.

Do you know one way or another as to whether Mr. Moore had it as well?

Mr. ALDRICH. I believe the question of O-ring erosion was known throughout the program for a number of flights, prior to last summer. It is really the severity of it and the implications of its interrelationship with the design that was not appreciated.

Senator RIEGLE. So you did not receive a message from the top down either, as you might properly have received it?

Mr. ALDRICH. I did not.

Senator RIEGLE. My time is nearly up. And I am going to want to pursue this because these are critical matters in my view, because I don't want these mistakes repeated, and the only way I know to make sure they are not going to be repeated is not only to change the management system, but to find out who violated the system and to see to it that they don't have a chance to do it again.

Senator GORTON. Senator Gore.

Senator GORE. Thank you, Mr. Chairman.

I would like to, first of all, just pick up where Senator Riegle left off and ask some questions about the communications system here. The Commission recommended improvements to the communications system.

Let me just ask you, shouldn't upper level management be aware of the criticality I items that most threaten the success of the mission, and shouldn't upper management know when there is a waiver of constraints as a result of those criticality I items, Dr. Fletcher?

Dr. FLETCHER. Senator Gore, of course, the answer is yes. Upper management should be aware of those things. Why they were not aware of the particular instance when it was changed from criticality I-R to criticality I in the case of the seals is a puzzlement, but I am sure that is one of the things that Captain Crippen is going to look very carefully at in his examination.

Senator GORE. How many criticality I launch constraints were waived? Each flight for the SRBs, the ET, the SSMEs, and orbiters; do you know, Mr. Aldrich?

Mr. ALDRICH. I believe Jack Lee has that figure.

Mr. LEE. On 51-L there were two criticality I launch constraints waived on the SRB; none on the external tank, five on the SSME.

Senator GORE. What were they?

Mr. LEE. Can I give you that for the record? I only have the number at this time. I have the area that they were waived in, but not the specifics associated with them.

Senator GORE. What was the other one on the SRB?

Mr. LEE. One was a transducer that required some torquing but, I am not certain of that torque value.

[The following information was subsequently received for the record:]

SSME CONSTRAINING PROBLEMS

PAS NO.	CRIT	OCCURRED ON	LIFTED ON	CLOSED ON	PROBLEM DESCRIPTION/CLOSURE DOCUMENT
A02481	1	SSFL	STS-1 STS-2	STS-2	HEAT EXCHANGER LEAK/FAR A018579
A02586	2R	STS-1	STS-1 STS-2	STS-2	CONTROLLER VOLTAGE LOW/FAR A012716
A03777	1	NSTL	STS-2 STS-3	STS-3	HPFTP BLADE FAILURE/FAR A018288
A04621	1	HSL	STS-4	STS-4	SOFTWARE BYPASSES SHUTDOWN STEPS/FAR A005946
A04945	2R	NSTL	STS-4	STS-4	HPOTP TEMPERATURE FID/FAR A006908
A05674	2	HSL	STS-6	STS-6	SOFTWARE OVERWRITE ANOMALY/FAR A004557
A06060	1	KSC FRF	STS-6	STS-6	MCC MANIFOLD CRACK/FAR A011709
A06142	1	KSC FRF	STS-6 STS-7 STS-8	STS-8	HEAT EXCHANGER LEAK/FAR A011736
A06201	3	KSC FRF	STS-6	STS-6	ASI LINE CRACK/FAR A011741
A06206	1	NSTL	STS-6	STS-6	ASI LINE CRACK/FAR A016680
A06220	1	NSTL	STS-6	STS-6	ASI LINE CRACK/FAR A016681
A06225	1	KSC FRF	STS-6	STS-6	ASI LINE CRACK/FAR A011740
A06612	1	CANOGA	STS-7 STS-8 41A 41B 41C	41C	AFV POPPET CRACK/A018503
A06512	3	NSTL	STS-8 41A	41A	HPFTP LINER BROKEN/FAR A006677
A07144	1	STS-8	41A	41A	ASI LINE RUPTURE/FAR A014689
A07586	1	NSTL	41C 41D 41G 51A 51C 51D	51D	HPOTP SUB SYNC/FAR A010038
A07835	1	NSTL	41C 41D 41G 51A 51C 51D	51D	HPOTP SUB SYNC/FAR A014818
A07935	2R	41D	41C	41C	CONTROLLER POWER SUPPLY SHORT/FAR A004955
A07936	1	41B	41C 41D	41D	OPB ASI LINE CONTAMINATION/FAR A004997
A07951	1	NSTL	41C	41C	HPFTP DISCHARGE TEMP/FAR A013332
A08018	1	NSTL	41C 41D 41G	41G	HPFTP LINER COLLAPSE/FAR A013338
A08145	2	41A	41D	41D	HPFTP IMPELLER CRACK/FAR A012842
A08186	2	CANOGA	41D	41D	HPFTP IMPELLER CRACK/FAR A015859
A08370	2	41D	41D 41G 51A 51C	51C	MFVA ABORT/FAR A004987
A08565	1	NSTL	41D 41G 51A 51C 51D 51B	51B	HPFTP IMPELLER CRACK/FAR A013000
A08781	2	NSTL	51A 51C	51C	MANIFOLD/NOZZLE TUBES SEPARATED/FAR A009908
A08994	1	NSTL	51D 51B 51G	51G	HPOTP SUB SYNC/FAR A006798

A09015	3 (MAS 1)	51D	51D 51B 51G 51F 51I	OPEN (NONCONSTRAINT)	GOX CV LEAK/FAR A017445
A09016	3 (MAS 1)	51D	51D 51B 51G 51F	OPEN (NONCONSTRAINT)	GOX CV LEAK/FAR A017446
A09078	1	SSFL	51D 51B 51G	51G	MCC OUTLET ELBOW FAILURE/FAR A015713
A09136	1	SSFL	51G 51F 51I	51I	MCC OUTLET RUPTURE/FAR A006786
A09196	1	51B	51G 51F 51I	51I	HPOTP CHIPPED BLADES/FAR A008530
A09302	2R	51F	51F 51J 61A 61B 61C 51L	OPEN (61E)	CCVA SLOW/FAR A010404
A09343	1R	51F	51I 51J	51G	IGNITER FID/FAR A010449
A09354	2R	51F	51I	51I	HPFTP TEMPERATURE SENSOR/FAR A006762
A09365	2R	51F	51I	51I	HPFTP TEMPERATURE SENSOR/FAR A006764
A09366	2R	51F	51I	51I	HPFTP TEMPERATURE SENSOR/FAR A008282
A09385	1R	51F	51I 51J	51J	IGNITER FID/FAR A010445
A09442	1	51I	51I 51J	51J	IGNITER FID/FAR A008289
A09482	1	CANOGA	51J 61A 61B 61C 51L	51L	IGNITER INTERMITTENT/FAR A013045
A09530	1	51I	51J 61A 61B 61C 51L	51L	HPFTP 1ST STAGE NOZZLE CONTAMINATION/FAR A010427
A09623	1	SSFL	61C 51L	OPEN (61E)	4000 HZ VIBRATION/FAR A010113
A09719	1	CANOGA	61C 51L	OPEN (61E)	HPOTP NO. 4 BEARING SPALLED/FAR A013872
A09720	2R	61B	61C 51L	51L	HPFTP TEMPERATURE SENSOR/FAR A013550
A09724	1	NSTL	61C 51L	OPEN (61E)	4000 HZ VIBRATION/FAR A009860
A09759	1	NSTL	51L	OPEN (61E)	4000 HZ VIBRATION/FAR A008921
A09876	2R	51L	51L	51L	CCVA FAILED SWITCHOVER/FAR A016629
A01640	1	STS-2	STS-1	STS-2	PROPELLANT CRACK/MTI REPORTS TWR 12879 AND TWR 1304
A07293	1	STS-8	41A 41B 41C 41D 41G 51A 51C	*51E 51D	NOZZLE EROSION/PROBLEM SUMMARY REPORT FOR DR4-5/23 TWR 11187-101
A07879	1	REFURBISHED HARDWARE	41C 41D	41G	S&A BB SWITCH CLOSURE TIME/MTI TWR 14217-2
A09150	1R	DM-6	51G 51F 51I 51J 61A 61B 61C	51L	IGNITER GASKET/MTI REPORT TWR 15351

A08698	1	41G	51A 51C 51D 51B 51G 51F 51I 51J 61A 61B 61C 51L	OPEN	OPT TORQUE/OPEN
*CANCELLED					
A09288	1R	51B	51G 51F 51I 51J 61A 61B 61C	OPEN	O-RING EROSION/OPEN
			*NOT LIFTED FOR 51L		
A09452	1	62A	NONE	OPEN	FWC TEST ARTICLE STA-2/OPEN
A09602	1	51J	61A 61B 61C 51L	OPEN	OUTER BOOT RING/OPEN

*MTI RECOMMENDED CLOSURE - MTI LETTER E100-86-26.

SRB CONSTRAINING PROBLEMS

PAS NO.	CRIT	OCCURRED ON	LIFTED ON	CLOSED ON	PROBLEM DESCRIPTION/CLOSURE DOCUMENT
A00584	1R	VENDOR	---	STS-1	MDM FAILED TO COMMUNICATE DURING IEA TESTING/ BENDIX DR 78410
A01158	1R	VENDOR	---	STS-1	RSS COMMAND DECODER HAD INTERMITTENT FAILURE/ AVCO PROBLEM REPORT AND MSFC FA EC33-80-001
A01209	1R	KSC BENCH TEST	STS-1	STS-1	FAILED IMAGE REJECTION/KSC PR PV400-5683
A01210	3	VENDOR	STS-1	STS-1	D15 MODULE OF MDM DID NOT RESPOND/BENDIX DR 79111
A01211	1R	VENDOR	---	STS-1	PIC HAD SRM IGNITION LOAD TEST FAILURE/ BENDIX DR 79123
A01315	1	MSFC TEST	---	STS-1	HEAT SHIELD - FIBERGLASS CLOTH 1582 HAD STRUC-TURAL FAILURE/SPEC CHANGE - CCBD S83-00-5106
A01410	3	STS-1	---	STS-1	HIGH RESISTANCE ON GROUND STRAP/PV400-5868, CCBD SB 3-00-4812A
A01833	3	VENDOR	STS-1	STS-1	MDM INTERNAL ERROR DETECTED/BENDIX DR 79347
A01853	1	MSFC TEST	---	STS-1	AFT HEAT SEAL CORK DEBOND/MSFC DR 3108
A01854	1	MSFC TEST	---	STS-1	AFT HEAT SEAL CORK DEBOND/MSFC DR 3107
A01902	1R	VENDOR	---	STS-1	APU CONTROLLER VOLTAGE OUT-OF-TOLERANCE/BENDIX DR 79362 WITH FA REPORT EC 430-80-21
A02409	1R	STS-1	STS-1	STS-1	APU SPEED CONTROL VALVE FAILURE/KSC PR PV400-8243
A02410	1R	STS-1	STS-1	STS-1	APU SPEED CONTROL VALVE FAILURE/KSC PR PV400-8244
A02472	3	STS-1	STS-1	STS-1	IEA FAILED CURRENT LEAKAGE/KSC PR PV400-8502
A02858	1	STS-1	---	STS-2	APU GEAR BOX LUBE HAD JELLED/MSFC DR 3473 AND ECN EP33-0440
A04337	1	STS-3	STS-3,-4	STS-5,-6	ACTUATOR ALIGNMENT FAILURE/KSC PR PV401-1401
A04404	1R	STS-3	STS-3, -4	STS-4	RGA C YAW SMRD DID NOT COME ON/KSC PR PV401-1524
A04708	1	STS-4	STS-4	STS-4	ROCK ACTUATOR EMITTING LOUD NOISE/PV401-2110. NOTE: PROBLEM ISOLATED TO GSE.
A04739	1	STS-4	STS-4	STS-4	ACTUATOR EMITTING LOUD NOISE/PV401-2153 NOTE: PROBLEM ISOLATED TO GSE.
A05086	1R	VENDOR	---	STS-6	APU HAD UNDERSPEED SHUTDOWN/USB1-HSV PR SS-0094
A05088	3	STS-4	STS-5,-6	STS-5	SRB SANK AFTER WATER IMPACT (STS-4)/PV100-1248 AND EO 326/12A00011-1/CCBD S83-00-7650A
A05089	3	STS-4	STS-5,-6	STS-5	SRB SANK AFTER WATER IMPACT (STS-4)/PV100-1249 AND EO 292/12A00012/CCBD S83-00-7650A

A05276	1	STS-5	STS-5	STS-6	DEFECTIVE HYDRAULIC PUMP/KSC PR PV401-3190
A05433	1	STS-5	STS-5	STS-6	SAFE AND ARM DEVICE SLOW TO ROTATE/KSC PR PV401-3571
A05549	1R	STS-6	---	STS-6	CABLE FAILED MEGGER TEST/KSC PR PV401-3892
A05720	1R	STS-5	STS-5	STS-6	RS RECEIVER HAD INTERMITTENT READINGS/KSC PR PV401-4398
A06518	1R	STS-7	STS-7	STS-7	CABLE CONNECTOR HAD ROUGH EDGES AND BURRS/ KSC PR PV401-6134
A07052	1R	STS-8	STS-8	41A	CABLE FAILED NO-GO PIC RESISTANCE TEST/KSC PR PV401-7178
A07713	1R	VENDOR	---	41B	INTEGRATED RECEIVER DECODER-STAKING COMPOUND OMITTED AROUND TRANSFORMER/CINCINATTI ELEC. PR 4144-61
A09119	1	51B	51B	51B	APU SCRAP HARDWARE INSTALLED/KSC PR PV402-0503
A09809	1R	61C	61C 51L	OPEN	APU - ABORT CAUSED BY RH TILT APU OVERSPEED/ OPEN

ET CONSTRAINING PROBLEMS

PAS NO.	CRIT	OCCURRED ON	LIFTED ON	CLOSED ON	PROBLEM DESCRIPTION/CLOSURE DOCUMENT
A01683	1	STS-1	STS-1	STS-2	BARRY MOUNT HAD EPOXY PRIMER LIFTOFF/MMC CAPS T-009
A02074	1	STS-3	STS-1	STS-2	INSTRUMENT ISLAND GAPS/MMC CAPS T-010
A01667	1	MAF	STS-1	STS-2	LEAKAGE AT LH2 MANHOLE COVER/MMC CAPS S-043
A02228	1	STS-1	STS-1	STS-2	PHENOLIC BLOCK ON CABLE TRAY DEBONDED FROM SUBSTRATE/ MMC CAPS T-017
A02312	1R	VENDOR	STS-1	STS-2	LO2 ULLAGE TRANSDUCER HAD CRACKED GLASS INSULATOR/ MMC CAPS E-045
A02506	1	VENDOR	STS-1	STS-2	GO2 MIDLINE ASSEMBLY LEAK/MMC CAPS P-038
A02556	1	STS-1	STS-1	STS-2	LH2 TANK ABLATOR PANELS DEBONDED/MMC CAPS T-019
A02535	1R	STS-1	STS-1	STS-2	LO2 ULLAGE TRANSDUCER HAD INTERMITTENT SIGNAL/ MMC CAPS E-048
A02667	3	STS-1	STS-1	STS-2	ECCO BOND CRACKS/MMC CAPS T-020
A02948	1	STS-1	-	STS-2	ET-1 TUMBLE SLOW OR NONEXISTENT (REENTRY PHASE)/ MMC CAPS P-039
A03581	1	STS-2	STS-2 -3 -4	STS-5	CRYOGENIC CONNECTOR FAILED TO REMAIN CONNECTED/ MMC CAPS E-051
A03580	1R	MAF	-	STS-2	NOSE CONE FLEX HOSE LEAKAGE/MMC CAPS E-054
A03607	1	STS-2	STS-2	STS-3	CONNECTOR SHIELD-TO-GROUND FAILED RESISTANCE TEST/ MMC CAPS E-057
A03970	1	STS-3	-	STS-3	LH2 VENT/RELIEF VALVE LEAKAGE/MMC CAPS P-041
A04617	1	MAF	STS-4 -5	STS-6	CONNECTOR MB6GE22-41SXT FAILED TORQUE REQUIREMENTS WHEN MATED WITH BACKSHELL MB-RFI-22/MMC CAPS E-058
A04468	3	STS-3	-	STS-3	TUMBLE VALVE RAIN SHIELD COVER WAS DETACHED/MMC CAPS P-042
A04769	1	STS-4	-	STS-4	LO2 FEEDLINE LEAKAGE/MMC CAPS P-043
A04857	1R	MAF	-	STS-4	SHORTED ECO SENSOR/MMC CAPS E-060
A05364	1	MAF	-	STS-6	LOX TANK PRIMER LIFTOFF/MMC CAPS T-030
A05365	1	MAF	STS-5	STS-6	DEFECTIVE SAFETY WIRE - RSS COAX CABLES/MMC CAPS E-061
A05275	1R	MAF	STS-5 -6	STS-7	DEFECTIVE CONNECTOR PIN SOCKET/MMC CAPS E-063
A05941	1R	MAF	-	STS-8	LO2 LEVEL SENSOR FAILED RESISTANCE TEST/MMC CAPS E-066
A05942	1	MAF	-	STS-6	CONNECTOR PINS PULLED OUT/MMC CAPS E-067
A05946	1R	STS-6	-	STS-6	WIRE SHORT TO SHIELD HARNESS/MMC CAPS E-068
A06077	1R	VENDOR	-	STS-6	LO2 LEVEL SENSOR HAD CRACKED TERMINAL/MMC CAPS E-071

A06195	1R	STS-6	STS-6	STS-7	LO2 ECO SENSOR HAD LOW RESISTANCE SHORT/MMC CAPS E-072
A06335	1R	STS-6	STS-7 -8 41A 41B	41C	LH2 100% LOAD LEVEL SENSOR FAILED/MMC CAPS E-073
A06655	1R	MAF	STS-7 -8 41A	41B	RSS CONNECTOR INTERNAL SLEEVE SEPARATED/MMC CAPS E-074
A06816	1R	STS-7	STS-8 41A	41B	LH2 ULLAGE PRESSURE TRANSDUCER STUCK/MMC CAPS E-077
A06743	2	MAF	41A 41B 41C 41D	41G	VOIDS IN FOAM/MMC CAPS T-034
A06905	1	MAF	STS-8 41A 41B 41C	41D	STAINS ON LH2 BARREL/MMC CAPS T-035
A06929	1R	MAF	STS-8 41A	41B	ACOUSTICAL FILTER NOT STAKED/MMC CAPS E-076
A07484	1	MAF	41A	41B	IMPROPER THREADS ON CRYOGENIC FEEDTHRU CONNECTOR/ MMC CAPS E-079
A07563	1	41A	41B 41C 41D 41G	51A	RSS BATTERY VOLTAGE SENSOR SHORTED TO GROUND/ MMC CAPS E-080
A07802	1	41B	41B 41C 41D 41G	51A	DELAMINATION ON CABLE TRAY COVER/MMC CAPS T-040
A07997	1	VENDOR	41C 41D	41G	LO2 LEVEL SENSOR FAILED RESISTANCE TEST/ MMC CAPS E-081-2
A08475	1R	41D	51A 51C 51D 51B 51G 51J 61A 61B 61C 51L	OPEN (61E)	LH2 ULLAGE PRESSURE TRANSDUCER MEASUREMENT ERRATIC/ MMC CAPS E-082 IS STILL OPEN
A08717	1	MAF	51A	51C	WIRE GAUGE MISIDENTIFIED/MMC CAPS E-084
A10051	1	MAF	-	OPEN (61E)	CLIP PARTIALLY SEPARATED FROM AFT DOME/MMC CAPS S-069 IS STILL OPEN
A10060	1	MAF	-	OPEN (61E)	NICKEL PALTING PEELING OFF GH2 GROUND STRAP/MMC CAPS P-054 IS STILL OPEN
A09937	1R	MAF	-	OPEN (61E)	ORIFICE FITTING MISIDENTIFIED/MMC CAPS E-097 IS STILL OPEN
A10000	1	MAF	-	OPEN (61E)	ELECTRICAL TEST EQUIPMENT FAILURE/MMC CAPS E-098 IS STILL OPEN
A10077	1	MAF	-	OPEN (61E)	MOISTURE SEEPING FROM GO2 PRESSURE LINE BELLOWS/ MMC CAPS P-053-1 IS STILL OPEN
A10079	1	MAF	-	OPEN (61E)	DEFECTIVE WELD ON LO2 FEEDLINE/MMC CAPS P-053-3 IS STILL OPEN
A10080	1	MAF	-	OPEN (61E)	LO2 FEEDLINE WAS UNDERCUT AND HAD DEFECTIVE WELD/ MMC CAPS P-053-4 IS STILL OPEN

Senator GORE. All right. If you would supply all of those Criticality I problems that were waived for the launch.

Who was informed of these waivers?

Dr. FLETCHER. There are two questions, Senator Gore. I think in the past, we can answer that one, either Arnie or Jack Lee. In the future, we are going to correct whatever deviations were made in the past.

Go ahead, Jack.

Mr. LEE. In the case of the launch constraints that were established by the Solid Rocket Booster Project Office—there is an internal system that allowed the establishment of a constraint for their own use in identifying problems.

The category of the launch constraint or the terminology of launch constraint was dropped within the Project Office when they considered that problem to be closed.

Now, the problem itself associated with that constrait went to other levels of review throughout the system, but were not identified as launch constraints after that. So the problem within themselves got discussed a number of times at different flight readiness reviews.

Senator GORE. Well, correct me if I am wrong, but the definition of launch constraint is that there is a problem that should be fixed before the next launch; correct?

Mr. LEE. Yes, sir.

Senator GORE. OK. Leaving aside this question which we will explore for the record, but in the future who should be informed of launch constraints? All the way up to the top, Dr. Fletcher?

Dr. FLETCHER. Of course, that is an issue that Captain Crippen will be looking at, but in my opinion yes, all the way up to the top.

Senator GORE. OK, fine.

Now, I am interested in how many other problems with the shuttle might reach the level of criticality that the O-rings represented. There were a number of other launch constraints. There are a number of other problems.

Do you have a sense that yet as to whether any of the others might be as serious as the O-ring problem?

Admiral TRULY. I think I will pass this to Mr. Aldrich, but I think that could probably best be answered by him in a brief description of what he is going through in the criticality I review. This review includes the flight history of these individual items and there are some items that we are considering, and undoubtedly will make changes to.

Senator GORE. Well, if it is going to be lengthy response, just supply that for the record if you would.

Let me ask you about one in particular and that has to do with the space shuttle main engine. In the NASA data and design analysis review, the finding was that the main engine is recognized as a high-technology, high-power density state-of-the-art rocket engine.

The mutual understanding of the complexity of the system and the attention of detail given has no doubt been an important factor in the success of the program to date.

Now, you mentioned that while there were two launch constraints on the SRB for flight 51-L, there were five launch constraints that were waived on the main engine.

Now, Aerospace Daily reported May 8:

Improper welds and cracks in fuel pump blades coincidentally discovered in the space shuttle main engine since the *Challenger* accident exceeded NASA's safety engines and would have grounded the fleet if the accident had not.

Do you agree with that, Mr. Aldrich?

Mr. LEE. I can answer that. I do not agree with that. I do not know the basis of it. I would be happy to determine that, though.

Senator GORE. Does anybody else want to comment on that?

Dr. FLETCHER. I think, Senator Gore, just a general comment. The space shuttle main engine did receive a lot more attention and concern than the solid rocket booster. It has always been—it is a very high technology engine and there were things like cracks in the blades, and so forth, that were always being carefully observed as the program went along.

Senator GORE. And there were shortcuts in the testing of the main engine, too, weren't there?

Dr. FLETCHER. I do not know about the shortcuts, but certainly there were concerns and that is why you find so many concerns or waivers in the case of the space shuttle main engine. It got a lot more attention because of the very high technology that was involved.

Now, the particular detail that you referred to, I am not aware of.

[The following information was subsequently received for the record:]

Further checking verifies that there were six launch constraints instead of five as previously indicated in Mr. Lee's testimony. The six, together with an assessment of each, and the ongoing corrective action are provided as follows:

Constraint	Assessment	Corrective action
One ball of HPOT No. 4 bearing found spalled during pump disassembly.	Similar spalling has been observed periodically throughout the program without incident.	Improvements have been made to significantly reduce the probability of a spalled ball.
4,000 Hz high vibration levels on engine 2025.	While certain ground test engines have experienced this problem, no engine has been used for flight that exhibited this characteristic. Engines with high vibrations can be identified in engine ground testing.	Tests are in progress to determine how flow resonant condition couples with splitter vanes to cause high vibrations. Also, a retrofittable fix for engines that exhibit 4,000 Hz vibration is in development.
Cracks found in LOX inlet splitter vanes on ground test engine 2116.	Cracks were determined to be results of MCC LOX flow resonant condition causing 4,000 Hz high vibration condition. The effect is vane cracking caused by high cycle fatigue. No engine has been used for flight that exhibits this characteristic.	Tests are in progress to determine how flow resonant condition couples with flow splitter vane to cause high vibrations. Also, a retrofittable fix for engines that exhibit 4,000 Hz vibration is in development.
4,000, Hz vibration observed on engine 2026.	The vibration amplitude was less than 15 G's and duration was less than five seconds. Because of the low amplitude and by analyses, this was not considered a problem on this engine.	Tests are in progress to determine how flow resonant condition couples with flow splitter vane to cause high vibration. Also, a retrofittable fix for engines that exhibit 4,000 Hz vibration is in development.
Intermitten firing of spark igniters was indicated during engine prelaunch checkout.	Igniters were returned to Rocketdyne for failure analysis. The igniters were extensively tested without incurring any failures. Also, six igniters were hot fire tested in an engine and were found to be satisfactory. All engine combustors have redundant spark igniters. No ignition problems have occurred in program.	None.

Constraint	Assessment	Corrective action
HPOT turbine housing sheet metal pad came loose and was found lodged against nozzle.	Sheet metal pad was not adequately spot welded.....	All flight HPOT's will be subject to additional inspections to assure that the metal pad is properly spot welded.

Senator GORE. Well, I would like you to elaborate on that for the record, if you would, each of the five launch constraints on the main engine and your assessment of how serious the problems are and what the fix might be.

Dr. Feynman also from the Commission also pointed out this particular problem and I will look forward to you elaborating on this for the record.

Now, in the area of quality assurance, I welcomed your statement in your opening remarks, Dr. Fletcher, indicating that you intend to move immediately to establish that separate Office of Quality Assurance and I think that is the kind of immediate action that is really needed here.

What about the number of quality assurance personnel? Do you intend to increase the number of quality assurance personnel in addition to establishing this new office?

Dr. FLETCHER. Well, Senator Gore, my feeling about it is that the number of personnel isn't the critical issue. The critical issue is the quality of personnel, the feedback that those personnel get from the quality assurance program from both the contractors and from the various quality control and safety people in the centers, and to make sure that plays well. That is the important thing.

If an increase in the number of personnel is required, that will certainly be done.

Senator GORE. Well, the Commission felt that the number was critical. One of the Commission's findings, and I quote, is: "Reductions in the number of safety, realibility and quality assurance work force at Marshall and NASA Headquarters have seriously limited capability in those vital functions."

You don't disagree with that, do you?

Dr. FLETCHER. No, I don't disagree with that.

Senator GORE. Well, isn't one of the fixes then to increase the number of people in the quality assurance work force?

Dr. FLETCHER. I think that is certainly one of the things you do, but as I indicated before, is how these people operate with the entire organization.

Senator GORE. But if you don't have enough of them, then they can operate perfectly and they still won't do the job.

Dr. FLETCHER. I have no question but that there should be an increase of quality assurance personnel in certain aspects of the program.

Senator GORE. All right. Well, I welcome that response.

Are you going to propose increasing the number in the 1987 budget?

Dr. FLETCHER. I think that is going to have to await a review of all of the management procedures. It is not a large expense, Senator Gore, and so it can easily be accommodated in the Fiscal 1987 budget.

Senator GORE. I would hope that if the President has ordered you to implement the recommendations of the Rogers Commission, it seems to me that that charge should be interpreted as an order to deal with this finding as well and to increase the number of quality assurance personnel.

I am recommending, I will say to the chairman, that we get a separate line item for quality assurance in the budget that comes from NASA to the Congress, so that we can track this very closely.

What do you think about that idea?

Dr. FLETCHER. I don't think that is a bad idea at all, Senator Gore. I think you ought to track all the aspects of what we do and that is certainly one of them.

Senator GORE. Well, I appreciate that.

Now, if you were given a choice today between having a fourth orbiter with all of the funding coming from other NASA programs or, on the other hand, not having a fourth orbiter, which choice would you make?

Dr. FLETCHER. That is a question that we are dealing with right now, Senator Gore, and as was indicated, this is a policy decision. I am really reluctant to, shall we say, take the cost of the fourth orbiter out of our hide. We do not have much hide left in NASA in my opinion. This is only my feeling and it does not represent that of the administration necessarily.

We are in a critical situation at NASA right now. We have had a bad accident. We are trying to fix what went wrong, and not just the technical fix, as you all indicated, but the communications and management fix. We really need a fourth orbiter. We need a replacement orbiter for the *Challenger,* not just because of the fleet needs, but because the country wants it.

We would be letting those that lost their lives down by not going ahead with the fourth orbiter. As I say, it is a crisis situation. It seems to me that in normal times a crisis situation demands a supplement to a budget of an agency like NASA.

Now, having said that, we are in an awkward situation with the Gramm-Rudman-Hollings bill, in that people have committed themselves to following that bill. The administration's position is following it without a tax increase, Senator Hollings, and that is the problem—how we fund that fourth orbiter—and that has not yet been resolved.

Senator GORE. But given that choice, you would say no fourth orbiter?

Dr. FLETCHER. It depends upon the details of that choice. But without knowing the details, I would not want to eat the entire cost of that fourth orbiter; no.

Senator GORE. So the answer would be that you would not want it. OK.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Dr. Fletcher, you talk about the Office of Safety, Reliability, and Quality Assurance. And it has been suggested in the past and today that if you fix responsibility to an office or to an associate administrator, that that somehow diffuses the instincts for safety elsewhere in the organization.

I don't happen to necessarily buy that, but of course it is possible. Now, to me, one of the keys on safety quality comes from the relationship between—the reporting relationship between the associate administrator and the administrator.

It is very difficult to make any comparison between NASA and the Peace Corps in its earlier days, and I will not try to stretch that. But one of the innovations of the early day Peace Corps, which was in a sense new, skeptically regarded as naive thousands of Americans all across the world, doing what people could not be sure what. So the question was, how do you make sure in a new agency, skeptically regarded by Congress, but more particularly within the agency, that mandates are carried out? That is not safety in this case or quality assurance, but quality of program.

So the Peace Corps started what was new in Government at that point. They started an Office of Evaluation and the key to it was not that it was an Office of Evaluation, but that its Director and his staff reported only to the Administrator. It was an "eyes only" situation. Only the Director of the Peace Corps or Sargent Shriver received that recommendation.

It did not pass through other areas of the Peace Corps. It would only go to the Director. Therefore, it could speak the truth totally. There could be no pressures on it. The Director, when he received it knew, in that he trusted the associate administrator—in this case, a fellow named Charley Peters—that he was telling the truth.

Charley Peters had no reason not to tell the truth because nobody could get at him except the Administrator. That would seem to be a trivial thing, but it worked out to be a very strong and powerful tool.

I wonder whether it is that kind of relationship that you expect from your office in the reporting procedure.

Dr. FLETCHER. Senator Rockefeller, I do not think the analogy that you made with the Peace Corps is a bad one. That describes fairly accurately my impression of the kind of office that we are going to try to set up.

It is an independent audit function, if you like, on how well safety and quality assurance, reliability and quality assurance is being carried out everywhere in the agency, not just in the centers, but at the contractors, and so forth.

It is an independent chain, if you like, to the Administrator to be sure that things are being done correctly. Having said that, that does not make automatically safety and reliability happen. The people that have to make that happen are the line people, the designers, the people that communicate, the managers, and so forth. This is an indpendent route on how well we are doing, what we are supposed to do, and the kind of person that leads that effort has got to be somebody that is respected by the entire organization.

I would like to think of it as somebody not with large amounts of troops supplying large amounts of data, but somebody that has an intimate knowledge of how the system works, is able to go round himself personally, and we call it kicking the tires, going around visiting the troops, seeing how the program is coming, asking questions, how are you doing here, and are you following this procedure, et cetera, et cetera. An independent chain of command if you like, much the same as you described the Peace Corps.

Senator ROCKEFELLER. Reporting only to you?

Dr. FLETCHER. Reporting to me; yes.

Senator ROCKEFELLER. And that would mean reporting only to you, that is, "eyes only," that report not being available to other senior officials at NASA, except at your discretion?

Dr. FLETCHER. I was just going to add, except at my discretion. I think there are times when you would want the results to be revealed to the rest of the organization, but in cases where it was sensitive, to me only.

I should add, and to my deputy as well.

Senator ROCKEFELLER. When you said "cases," what was your phrasing?

Dr. FLETCHER. Well, for example, there may be very sensitive cases, in which case he would want to report to me directly without anybody else being aware of it. That is the nature——

Senator ROCKEFELLER. That is the point I am trying to make.

Dr. FLETCHER. But there may be other cases where he may be reporting to me and it should be made known to other individuals that they are in error, and that should be reported back to them.

Senator ROCKEFELLER. But that would be at your discretion? In other words, the initial thrust would come only to you and at your discretion you would go to those affected?

Dr. FLETCHER. That description, Senator Rockefeller, fits my goals; yes.

Senator ROCKEFELLER. I think that will be very useful and a very important matter of quality assurance. I think that will help a great deal.

The last time you were before us, Dr. Fletcher, you described your own concern that NASA not be taken over by the Department of Defense, and you and I have talked about that privately since that time.

There appeared to be even more pressures—budgetary pressures, SDI pressures, a truck shuttle, large capacity launch shuttle in the wings. It has been suggested by SDI people that there would have to literally be 50,000 launches at the current rate to get SDI working.

Well, we were at 24 launches, and now we are reportedly down to 12, so that would seem to put the military dimension not only in the forefront which it has on the priority basis anyway, but an even greater sense of priority.

You worried about that last time. You mused about it; were concerned that it not happen, and now you have made reference to our new budget restraints. SDI continues to be a priority of the President. He is going to be in office for another 2½ years.

Does your concern about military predominance within NASA, is it as strong as it was before, or perhaps stronger?

Dr. FLETCHER. Senator Rockefeller, you raise a good question, but if you don't mind, I would like to divide it into two parts. One is what the SDI needs will be, if and when it becomes operational. I think that is what was referred to when they said large amounts of flights will be required of the shuttle.

I think that is a brandnew ballgame when that takes place, and I would hope a different transportation system than the shuttle would be indicated. However, during this technology phase, which

is the phase we are in, there will be pressure, of course, to use th shuttle for SDI purposes.

I intend to keep a good balance between that pressure and th pressure from the scientific community and others to make sur that we have a balanced program on the shuttle. Remember, it i only 1992 on our current schedule that we begin to assemble th space station. And the shuttle, if it is a four-orbiter fleet, will b hard pressed to even just take care of the space station, let alon SDI and other needs.

So with three shuttles, it looks very difficult.

Senator ROCKEFELLER. Are you in a position to control how that works out?

Dr. FLETCHER. Senator Rockefeller, at this point I and my noteworthy assistant, Associate Administrator Admiral Dick Truly, I should leave the Admiral out, because he is a NASA person right now and he is doing very well at working the delicate balance between all of the different users, the NASA users, the operational users like the TDRS, the scientific users, and the military users.

Senator ROCKEFELLER. One final question. We have talked about the military use, we have talked about the requirements of NASA itself and launches, et cetera.

There is also medical use. The last time you discussed scientific use—Voyagers, the telescopes.

Dr. FLETCHER. I include medicine as a science.

Senator ROCKEFELLER. I want to differentiate that just a little bit because it seems to me that the cure for cancer, the cure for anemia, various experiments that are planned for space or some of which have been started that are noncommercial, nonmilitary, nonspace-oriented in the sense of telescopes or Voyagers, but simply medical—cures of major diseases, zero gravity benefits which come up there which cannot be duplicated at length at scientific laboratories on Earth—that they have an enormous importance.

I truly worry about their future. I think science as a total is 10 percent of the NASA budget now. What part of that medical experiments would be, I don't know, but it must be an awful lot less.

Are you committed to seeing that medical science experiments in space, for example, the cure for cancer, for example, the cure for anemia about which there is hope on both fronts in space, that those will be continued?

Dr. FLETCHER. Senator Rockefeller, I give you my word that those will be continued. They are a very firm part of our planning process that Admiral Truly, even in the early phases when we start up, is including very seriously in the planning process.

Senator ROCKEFELLER. But they are last on the priority list.

Dr. FLETCHER. I would not say that; no.

Senator ROCKEFELLER. Officially they are last. Designated launch priorities, they come last.

Admiral TRULY. When we started into the job of manifesting, we did set general priorities, the first being national security, the second being large scientific payloads that have specific launch windows, and then finally—then, if I remember precisely, finally our commitments to commercial and foreign satellite users.

However, when we get into the details of the manifesting process, it is a terribly complicated thing and we find ourselves with demands from each of these areas—national security, science, and so forth.

And your specific question, in medical science we do have a spacelab, life sciences spacelab, that is very high on the NASA science priority list in their demands. We need it very badly because as we look forward to the space station we think that that is an important primary mission.

The difficulty is with the down time and the lower flight rates. It does have to compete with major national security payloads and so forth. But I can assure you that, even though, as an example, some of our DOD payloads have a high priority, they are not going to all fly before the next category.

As a matter of fact, I have said before, and as complex as it still is, I think that in the first year or 18 months we are going to serve all of these, what I would call policy categories of customers. But I must also say very forthrightly that we are not going to satisfy any of them in those first few months, because of the limitations in the payload bays of the orbiter.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Senator GORTON. Senator Hollings.

Senator HOLLINGS. Let me ask, Captain Crippen, would you come around and sit next to Mr. Aldrich there. And Captain, what I want to know is what happened. I along with everyone, agree as to what scientifically and technically happened with respect to the O-ring and the weather problem, all joining together to cause this disaster.

I am also of the mind there was no venality or malice or intentional injury done to our astronaut friends. And yet, at the same time there is gross negligence. This lack of communications and everything else comes in to where in my opinion, unless we can determine it and clean that up—the expression used by Dr. Fletcher is "clean up and recovery"—that all of these folks who are engaged in the clean up and recovery—I'm not talking about the clean up and recovery of the damaged parts of the shuttle that were recovered and cleaned up and what have you.

I am talking about the system. And you have been in the system, and I took note of your comment at the particular time that, rather than the contractor justifying why to fly and being cross-examined in the press and by NASA, as the system normally responded and required, that rather the contractor was having to justify why not to fly.

So with that little prelude, just tell us, what do you think a Senator ought to know, what happened, so we can make sure that it does not happen again. And I am not talking about the technical part. I am talking about the human part.

I do not believe in this so-called safety office or whatever it is and letting them put some one around to watch everybody. It is more than that, somehow, as Arnie Aldrich has already testified now, and what I have always suspected, that the system was not flawed or the process flawed; it was violated.

But let me hear from you what happened. Now, you have been in on the investigation since the very beginning, according to Dr. Fletcher. What happened and what should we do about it?

Captain CRIPPEN. Senator Hollings, your objective is the same as mine and the same as the rest of these gentlemen at the table. I think it was the same as the Commission. But we perhaps all view that in a different way.

If I may, I would like to at least put straight on the record the comment that you were referring to that I made. It occurred in a closed hearing of the Commission. The occasion was the initial review of the meeting that occurred the night prior to the launch between Morton Thiokol and NASA. And that was when I and most people first learned of that particular conversation.

My statement was made in regard that I have been with NASA since 1969 and every launch that I have participated in or observed the launch review process, the entire thing is for the contractor and the project management to come forth and prove they are ready to fly. I believed that was the case on 51-L.

However, in listening to the remarks that were being made about the conversation that occurred the night prior between Morton Thiokol and NASA, I observed to Chairman Rogers that it appeared that, in this particular instance, the contractor was being placed in the position of having to prove that he was not ready to fly; and if that had occurred, I thought NASA had made a grave error.

It is difficult to establish the contractor position, because it is a big company. There were certain individuals that were trying to come forth and say that. And as Admiral Truly indicated, one of the most important findings that came out of the Commission report was communication.

And that is just a word, but obviously communication was not flowing properly from the bottom up or from top down. And why that was happening, I do not know. I wish I did. I have reviewed the system several times over and it is not obvious to me.

Now, trying to fix blame, I find it difficult to do that. I end up having to blame the system. We were not doing something right. And it is my objective in the assignment that Admiral Truly has given me to try and correct that.

Senator HOLLINGS. Well, you find then that communications—and I guess Admiral Truly agrees with you, because I think he testified over on the House side—that up there, that if they communicated to him a defect on one of the flights he took or a violation of a criticality one condition there, that he would have closed it down and not taken the flight.

Admiral Truly, you were not communicated to properly, were you?

Admiral TRULY. Yes, sir; that is essentially right. The question had to do with the erosion on the second shuttle flight, which I flew aboard, and it turned out that that erosion of the primary O-ring was the most serious erosion. And my answer was that, had on that day I been in charge and had we known—and this is very important—had we known on that day what we know now after the accident, after our thousands of tests that have been done by some of the members that are here today, how that joint per-

formed, that we should have stopped the Shuttle Program right there, fixed the problem, then gone on with it.

Senator HOLLINGS. And that again, as Captain Crippen has attested, is a lack of communication. You did not know.

Admiral TRULY. To be truthful, at that time I think it is true that I did not know about it until I came back to this job and after the accident. However, I think on the first event, and not having done all of that testing at that time, that would have been a difficult conclusion to come to at that first event.

But there is no question that, as the Commission and the NASA Task Force has unfolded the events leading up to the accident, I have to agree with Captain Crippen. The problem—and I realize this is difficult to accept, but it is still what I believe.

The problem was in the system, and the problem was a loss of discipline in using the launch review process and the program management process that has served us so well.

Within hours after the President gave his letter last Friday to Dr. Fletcher, I sent out a message to the various program offices and to the centers on initial steps as to how to set in motion a recovery procedure. And I said in there that the directives that go out and the information that comes back is going to go through the level 2 office, which is what I had always assumed had.

Senator HOLLINGS. Captain Crippen, really, you say a communications problem. But is it not the case that the individuals there, the engineers, in one statement I think they said there was not a single prolaunch statement in that room, or at least Allan McDonald was saying not to launch and he was communicating.

Why was he being overridden so vigorously and violently by the Marshall folks?

Captain CRIPPEN. I am not sure I know the answer to that. I saw Mr. McDonald quoted in this weekend's paper where he also was aware of a problem with the erosion of the O-rings. He knew that it had been occurring on all of these flights, and he also was saying that it was OK to go fly.

That had been the position, that the O-ring problem had been occurring down the line, we have lots of evidence of it, and at least the individuals that were looking at it thought there was enough margin of safety still there. That was still, in my opinion, not being conveyed throughout the rest of the system.

But Mr. McDonald apparently was at least aware of it to that degree, and it was only when combined with the cold temperatures preceding the launch that apparently those factors being combined were the ones that caused him to be concerned.

Obviously, some engineers and managers—and incidentally, most of the managers were engineers, both on the Morton Thiokol and NASA side—obviously did not reach the same conclusion. I think every one of them that were sitting in that room wishes they had a chance to change their mind now, but obviously that is not the case.

Senator HOLLINGS. Well, you know, in fairness to Mr. McDonald, I think the record is replete that he was the one objecting, that he was not approving. In fact, that is where the testimony came out here in this particular hearing room by Dr. Graham saying that the person charged with the responsibility of signing off and recom-

mending launch recommended it. And he was on the telephone saying:

> Oh, no; I am the fellow who is responsible and I absolutely refuse to recommend launch, and Dr. Graham of NASA knows that because I testified to that the previous Friday in the closed hearing.

So that is pretty clear to me.

Mr. Aldrich, was there any kind of—what was the pressure on this particular occasion where you have just that, everybody knowing exactly why. Everybody knew about the O-ring problem. In other words, it is not—well, I will just complete that thought.

When they say on page 82 of the Rogers Commission report:

> 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.

They were not aware? We know differently. That finding by the Commission is inaccurate, and we will have a chance to show that out if we want to. But these are the kinds of things, going right on down the list with respect to the report of the Commission, where again on page 145 that they say, Mr. Beggs:

> I had no specific concerns with the joints, the O-rings, or the putty.

This is contradicted by the document in the Commission's possession that the O-ring charring is a major agenda item for August 1985 between Mr. Beggs and Mr. Moore. And so I could go right on through here and make those corrections.

But I am trying to find out, Mr. Aldrich, do you have any reason now on reflection to know why you weren't communicated with on these particular things? For example, they had some 14 different conversations, calls back and forth, the evening before between Morton Thiokol, Marshall, and the center, and yet none of that got to you.

What is your explanation of that?

Mr. ALDRICH. Mr. Hollings, I have thought about this many times since the accident and I have thought about our system. And it is a system that has been in existence at NASA for a long time, and I had great confidence in it. It is a system that I do not believe has perceptibly changed at any point in time prior to 51-L.

When you couple that with my knowledge of the people at the Marshall Center that were responsible in these areas, Mr. Hardy and Mr. Mulloy and Mr. Reinartz—I have worked in past programs at NASA, the Skylab Program and the Apollo Program, with these individuals, and had the highest respect for their technical competence.

So why we came to this point in a system that I believe in and the people who were responsible in the program for these significant technical matters, and yet we were not able to communicate in a way that we all understood the issues on the table, I cannot answer.

The fact is, those items were not brought forward the night before the launch, even though Mr. Mulloy called me and talked about two other items, the ice on the launch pad, on the launch complex, and the sea state at sea. We had a discussion on that late that evening following this long deliberation on the SRM seals.

It is amazing to me that our system by its very familiarity and use and process did not allow all of this communication to happen. But it did not.

Senator HOLLINGS. Thank you, Mr. Chairman.

Senator GORTON. Thank you.

Now, at this point, members, each may ask whatever questions he wishes. We are not going to time the second round.

Both Admiral Truly and Dr. Fletcher have talked about and endorsed the concept of a shuttle safety panel. Senator Hollings has concerns about that on the ground that by assigning safety specifically to a particular group there will be a loss of concern over that on the part of other people within NASA.

I would like either or both of you to comment on that, how it would differ from the current aerospace safety advisory panel, and what kind of responsibilities and day to day functions it will have.

Dr. FLETCHER. Mr. Chairman, there is always the danger if you are not careful that you set up a crutch to solve a problem, and that people then relax, thinking that the crutch will solve the problem.

The only way you can solve that problem is to make sure that everybody in the direct chain of management feels a responsibility for doing his job correctly. This is a motivation and I would say a dedication problem. All of the people in the chain of command that we talked about earlier today have got to feel a direct responsibility for his part of the job.

That means communicating both up and down, making the appropriate judgment, if he has some concerns, letting them be known, and so forth. That is the only way you can make something work and work reliably. And that is the main thing I have tried to emphasize.

This other is an audit function to make sure. It is a double check, if you like, to make sure that everybody has done his job all up and down the line, and if there are some concerns along the way, that it has a separate channel to be fed to top management, which is me.

Senator GORTON. Ok. If I could interrupt, it is not going to have a veto power in and of itself? It will have a separate channel to get to Admiral Truly and to you, to relay these concerns before a launch decision is made, am I correct?

Dr. FLETCHER. It will not have a veto power in the normal sense. We may, although this will have to be dealt with in some depth—we are not going to just appoint a person and then go away and leave it. We are going to get the best experts in the country to help that person do his job.

It may turn out that he will be a part of the launch team, and if he has some concerns, he will refer those concerns to, in the case of the launch, the flight director and the mission control, the mission director later. But we have not made that decision yet.

Mostly, he will be reporting to me, and of course in principle I have the power to stop the flight also. But generally speaking, it is done at the level one, which is the program AA, which is Admiral Truly.

Senator GORTON. Do you have anything to add to that, Admiral?

Admiral TRULY. Well, very briefly, I must say that I think there is a good argument on both sides that we have heard this morning. And I have to agree with Senator Hollings that a safety office does not make in itself safety.

On the other hand, I think that I welcome the recommendation in the Commission report that says in the Office of Space Flight, I should have, and I forgot the words, but a safety panel, because that guarantees an open door directly to me.

I see it more, though, than a panel that would sit there by itself. I see it as internal to the Office of Space Flight, an organization, but not additional people, people in the working organizations that could flow or could feel free to flow safety-related information up and down.

As a matter of fact, if I may go back, one of the most challenging situations for safety and yet one of the safest operations is to watch a Navy carrier at sea. You have there a situation where you very much need safety, and it cannot stop with the safety officer. It must go through the pilots and the flight deck personnel and the handling personnel, and it must be ingrained into the system.

And that is the kind of system I think in the Shuttle Program that we need. Frankly, I think also on the subject of safety that we have taken some unfair licks. I know that in the 14 years that I was in the astronaut office I would say, if there was any single subject that permeated more the technical discussions, be it hardware design or operational procedures, safety was that point.

And it was not just between people in the office, but people in the engineering end of the program. But this one got away from us, and we are going to make sure that it never does again.

And so I welcome this little safety panel. It is not going to be a big one, but it is going to have my ear.

Senator GORTON. I would like to ask you particularly, Admiral Truly, about launch abort and crew escape. There are two recommendations from the Rogers Commission in that connection.

But I first simply want to ask you whether or not you agree with the Rogers Commission that there is simply no survivable crew escape options during the first 2 minutes after launch, while the solid rocket boosters are still active, before they have been released? Do you agree with that at least implicit conclusion of the Rogers Commission?

Admiral TRULY. I do.

Senator GORTON. But immediately thereafter, while the main engines are still in operation, the situation has changed to a certain degree?

Admiral TRULY. I think there is a possibility for crew escape and egress improvement during gliding flight. We do have—and I might ask Mr. Aldrich to give you a brief status on that, we do have a fairly extensive reexamination of those options underway in Houston. That study is going to be underway for some time.

I think at one point it was publicized that they were going to have a report on the 15th of this month, which was a couple of days ago, and that was inaccurate. We are going to have them status to the level two, to Mr. Aldrich, the status of their work here, and I think that is scheduled in the next couple of weeks.

And we would be pleased to, at the appropriate time, to brief you and your subcommittee on that.

Senator GORTON. I would be happy to have you do that.

And I would like to have Mr. Aldrich's comments on both of the recommendations of the Rogers Commission, the gliding flight and the main engine failure, if you could briefly summarize where you are on those at the present time.

Mr. ALDRICH. Several times in the past program we have assessed the question you asked earlier about the first stage abort during the first 2 minutes. I agree with Admiral Truly. I do not think we are going to come up with something that is practical or reasonable that can be added to the shuttle system for that.

The team, however, is looking at all phases of escape beyond that 2 minutes for augmentation and in particular the kind of aborts we have called up to now contingency aborts, where you are able to separate from the remaining propulsive elements and glide the orbiter down to a flat and level glide above the ocean but not be able to arrive at a runway.

There are several techniques for coming out of the spacecraft before it hits the water which appear to be more safe in terms of survivability than staying with the vehicle and ditching. They involve both active and nonactive means of coming out through perhaps a new hatch in the vehicle to allow the crew to use a parachute and come down to the water. We are looking at those very strongly.

They have been looked at also in the program in the past, but there are some new ideas and some new technology that may in fact give us the ability to deal with that kind of an escape for a crew as large as the size which we have been flying in the shuttle.

There is also one other mode that we may be able to implement in the flight software. It is called a split S maneuver, and it is being looked at for a very early return to the return to launch site landing at the cape during a regime where you had more than one main engine out. We had previously thought that you would not be able to return for that, and so that is another area where we hope perhaps to augment our current capability.

The effort of this team and its subteams is to look at all aspects of crew survival and escape for the entire assent and reentry phase of flight.

Senator GORTON. Admiral Truly, while you are going through this entire shuttle reevaluation, what priority and what concern do you have about the necessity for changes in the shuttle main engines? Are they fundamental and major changes which will involve a lot of cost and time or relatively minor such changes?

Admiral TRULY. The main engine is a high precision, high-performance instrument, but I have no personal intentions one way or another. I am going to let the system do its job through the critical items review. I am a great believer in testing.

Incidentally, I should tell you that we are back into single engine testing in Mississippi and conducted the first single engine test since the accident a few days ago. We specifically are doing that testing to look at a particular problem that has shown up in some test engines, and that is a 4,000-cycle-per-second vibration that has

been detected. We have heavily instrumented the engine and are getting into tests to do that.

So we are going to pay particular attention to the engines, but I cannot predict to you today precisely how that will continue to play out with regard to dollars.

Senator GORTON. Thank you.

Gentlemen, I have literally dozens of additional questions which I am going to submit to you in writing, as I have a noon engagement and I am going to turn this hearing over to Senator Riegle now to complete all such oral questioning as he wishes. He will then adjourn the meeting.

Senator Riegle.

Senator RIEGLE [presiding]. Thank you, Mr. Chairman.

Dr. Fletcher, earlier you heard Mr. Aldrich indicate that under the proper procedures within NASA he should have been informed by Mr. Reinartz or Mr. Mulloy about the disagreement, the problem with the O-rings and so forth prior to the launch.

They had an affirmative obligation to report and did not report that information to him. Is that your understanding as well?

Dr. FLETCHER. Yes; Senator Riegle, it is my understanding. Although I have not been close to it, I have talked to the individuals involved, and I have read the Rogers Commission report. I am as surprised as Mr. Aldrich.

Senator RIEGLE. Now, knowing that now as you do, have you taken any disciplinary action against those individuals, or do you plan to?

Dr. FLETCHER. Senator Riegle, I hate to use the civil service analogy, but we do evaluate people regularly in our procedures. We use a personnel evaluation system, and so any errors on the part of the various individuals involved—and there were a lot of individuals involved up and down, as you have heard—especially an error of this severity, will be taken into account in their evaluation report, and it will be accounted for in their record and future promotions and so forth.

Having said that, however, reference has been made to people in the decisionmaking loop. In the future, we plan to put individuals in that loop who are not only going to follow procedures but communicate well up and down so that we have a team operating and not a series of individuals.

Senator RIEGLE. Does that mean that all of the individuals that you identify who have behaved improperly will be taken out of the decision loop in the future?

Dr. FLETCHER. I cannot say for certain that all of the people who have been identified, because I do not believe that all of them have been identified, but certainly for the foreseeable future, the near future, that has been done. I see no reason to change that.

I want to reserve, however, the option of making changes in the future as the situation demands, not making a commitment that lasts forever here in this meeting.

Senator RIEGLE. I think this situation is unique in terms of the gravity of the consequences, the loss of seven astronauts, the destruction of at least 3 billion dollars' worth of very vital and irreplaceable national security assets, at least not replaceable within any kind of a short timeframe.

It seems to me the gravity of the error here is of an extraordinary sort, and I must say that I am troubled about that. I think there almost seems to be less concern about that than there is about the delicacy with which we deal with individuals in the chain of command who had a direct responsibility in this accident. I will just aim this at you, and I am making a general observation about that fact.

I must say I am hard pressed to reconcile those things when I hear Mr. Aldrich say that under the management system there was an affirmative obligation for Mr. Mulloy and Mr. Reinartz to inform him of the special dangers that have been brought to their knowledge about the cold temperatures and the O-rings. They did not do so, and the launch went ahead and seven people were killed.

That, to me, is a very, very serious failure on their part. I think it requires direct disciplinary action. I am somewhat at a loss to understand why that is not the view within NASA. Perhaps it is. If it is, I would like to hear it, but if it is not I would like to hear what the thinking is with respect to those individuals.

Particularly, I want to get to the rest up and down the line, but let us take those two because they are directly in the center of this and are part of the nexis of that decision chain that broke down.

Dr. FLETCHER. Senator Riegle, they have been removed from the chain of command, and they will be disciplined in accordance with the procedures that we always follow. I do not know what you are implying. Are you implying punishment in the sense of a criminal indictment?

Senator RIEGLE. No; I have been very careful not to say that, and I have not said that at any time. What I am concerned about here is whether or not, having identified the individuals who behaved improperly with the result in the end that we had a fatal accident to others, what disciplinary steps are being taken in the cases of those individuals?

I think the public needs to know the answer to that, and certainly we need to know the answer to that. Now you have said to me that apparently disciplinary actions have been taken against those two individuals. Am I correct in understanding that?

Dr. FLETCHER. I would not call it disciplinary action, but they have been removed from the chain of command. They will have in their record an indication of the mistakes and gravity of the mistakes that they made. I think that is about as far as the civil service system allows us to go, Senator Riegle, but maybe you have some further thoughts on that.

Senator RIEGLE. Is there any conceivable justification, with the facts being known now as they are, for those individuals not to have conveyed that information to Mr. Aldrich and perhaps to others prior to that launch?

Dr. FLETCHER. I think I had better turn that one over to Admiral Truly and his associate, Senator.

I am surprised that that was not done. I have come from the outside, but I have not really probed deeply, and I have not talked to the individuals involved personally. I am surprised that there was not better communication up and down the line. It is not just the two individuals that you mentioned. It is a whole series of individuals.

Senator RIEGLE. I do not know if you want to comment on that, Admiral Truly, or not because I do not mean to begin or end with those two individuals. I am starting with them, but I intend to move on up and down that list with you.

Is there any proper explanation?

Admiral TRULY. No. I would have to agree both with Dr. Fletcher and particularly with what Mr. Aldrich said earlier with the gravity of the situation. All of us associated with the investigation were surprised and terribly sorry that that particular instance in this long chain of events that led to the accident did not elevate that decision at least to the level II and then presumably to level I so that it could be dealt with, the launch warning as a result of the circumstances with the weather the night before.

Senator RIEGLE. Mr. Aldrich, as you understand it, did Mr. Lucas have this information also the night before the launch?

Mr. ALDRICH. My understanding is that Mr. Lucas had knowledge early in the evening that such a meeting was going to take place on that subject, and then very early the following morning in the countdown a summary of the discussion was presented to him so he knew that the results were concluded. As we understand, they were concluded.

Senator RIEGLE. To the extent that he was aware of these disagreements and problems and this controversy, as the NASA rules work, as they are designed to work, would he have had an affirmative obligation to report that to others?

Mr. ALDRICH. That is hard for me to answer because he was there in the firing room with us, and he had this information; however, he is not in the normal reporting chain of the program for problems. So it is hard for me to say that he would have been required to report; however, our process is normally to discuss all things that have come up during the countdown, the final few hours, and to be sure that we understand how we have resolved them. The fact that that discussion was not entered into, to me, is disappointing.

Senator RIEGLE. So he had this information and did not pass it on to you, but it is vague in your mind as to whether he had any specific management requirement to do so, is that correct?

Mr. ALDRICH. In the reporting chain, he is not directly responsible to do so. It would be the project personnel we have already discussed and his organization who are also there who should have been required to do that.

Senator RIEGLE. At the same time, you expressed surprise that he did not inform you on a matter of this consequence.

Mr. ALDRICH. Surprised that either he or one of his personnel did not raise that discussion in the firing room on launch morning.

Senator RIEGLE. Dr. Fletcher.

Dr. FLETCHER. Senator Riegle, just to clarify things, generally speaking there is a well-defined chain of command through the program, which in this case would be Admiral Truly down through level II which would be Mr. Aldrich, and then level III which would be some place in Marshall, probably Mr. Mulloy. That is the normal well-defined chain of command, and that is the way the project organization works.

We are a team, however, and all members of a team are expected to express opinions. So even though Dr. Lucas was not in the chain of command, I guess I would have expected him to speak up if he had serious concerns about the launch. That would be true of myself, and I am not in the chain of command, either. If I had concerns, I would feel free to express them to Admiral Truly or anybody else in the chain; probably Admiral Truly, since he directly reports to me.

So even though there is a direct chain of command, the whole NASA organization is a team, and we ought to have open and frank discussions with each other on problems of this magnitude.

I hope this clarifies things.

Senator RIEGLE. It is becoming clearer as we move along here.

Mr. Lee, let me ask you. You were informed prior to the launch of the discussions the night before and apparently the strong disagreements on the part of some that temperatures were too cold and it was too dangerous. Is that correct?

Mr. LEE. No, sir, I was not in that discussion.

Senator RIEGLE. Are we talking about another Lee? It is indicated in the Commission report that approximately 8 a.m. in the morning Lovingood informs Lee of previous night discussions.

Is that inaccurate?

Mr. LEE. No; that is accurate. That is true.

Senator RIEGLE. What did you learn?

Mr. LEE. I am unsure of that. I did not read that testimony.

Senator RIEGLE. What do you recall Mr. Lovingood saying to you that morning?

Mr. LEE. I believe it was to the effect that they had had a discussion with Thiokol, and it had been resolved with a recommendation on the part of Thiokol management to proceed. I believe Mr. Hardy had a copy of that telex, and that was the extent of my involvement in it.

Senator RIEGLE. Were you given any sense that there was a long, heated argument the night before? Was any of the flavor of the intensity of that disagreement conveyed to you?

Mr. LEE. No, sir.

Senator RIEGLE. Were you informed of the fact that there was an unusual procedure used to acquire that signoff, namely that McDonald, the man onsite who would normally do it, was bypassed and this fax came in from Utah?

Mr. LEE. No, sir.

Senator RIEGLE. Would you have expected to have been told those things? Should you have been told those things?

Mr. LEE. Ordinarily, the way we work these, I stay in Huntsville. When we have early morning launches, I come in just for the latter part of the launch because most of the other people, the ones at the cape, specifically Dr. Lucas and that management team, have usually been up longer.

So I only attend the launch portion so that then I can carry on with the Center business the rest of that day in the event that there are launch delays. This is the kind of a routine that we have worked out.

Senator RIEGLE. You were given no information by Mr. Lovingood that there was a concern about the low temperatures and the O-ring problem?

Mr. LEE. No, sir, other than the fact he mentioned that they had a discussion and they had the written recommendation from Thiokol which was to launch, which is normal in our process.

Senator RIEGLE. Under the circumstances, knowing the background here, is it your view that you should have been informed by Mr. Lovingood?

Mr. LEE. I would say no, based upon the fact that I am not in the launch processing chain, and the launch team works offline from me in that respect.

Senator RIEGLE. Earlier you indicated that there were other individuals up and down the line who did not perform properly in the management chain here. Who did you have in mind when you made that comment, Dr. Fletcher?

Dr. FLETCHER. It is hard to identify individuals, but certainly information about the seriousness of the seal problem was known in headquarters, and I do not know all the people that were aware of the problem.

It is just a little surprising to me that that information was not communicated down through Mr. Aldrich somehow. Of course, he was, you might say, new on board. This is a terrible thing to conjecture, but they may have assumed he knew it, not realizing that he was a recent arrival.

Whatever the case, that communication should have been done from headquarters, and there were a number of people in headquarters who were aware of the seriousness of the problem.

Senator RIEGLE. Is Mr. Weeks one of those people?

Dr. FLETCHER. Mr. Weeks is certainly one of the people. I am not sure he is the only person involved.

Senator RIEGLE. Is an effort underway to identify who else should have known and should have communicated?

Dr. FLETCHER. We have had discussions on this subject. I will have to turn that over to Admiral Truly. We know some of the individuals who were aware of it, but I am not sure we have a complete picture of all the people.

Admiral TRULY. Senator Riegle, I base my knowledge of this entire meeting and episode on the testimony that the Rogers Commission took.

I think the clear breakdown in my view in the management system is that level I was dealing technically with level III directly rather than through level II up and down. That is not the way that I thought the system worked. It is certainly not going to be the way the system worked. It is certainly not going to be the way the system works from now on.

Even though there are many funding things, budgeting things that may be very appropriately worked directly between my office and the level III project office, it certainly would not be without level II being involved. So, to me, that is the breakdown.

In answer to your specific question, other than the individuals who were in responsible positions at that time, which were Mr. Moore, who was the Associate Administrator, and Dr. Weeks, who is the deputy for technical matters, and Mr. Winterhalter, who is

Head of the Propulsion Division, I do not have any specific effort underway beyond the Commission report.

They have done their investigation and taken their testimony, and I do not have any other investigation, internal or external, underway.

Senator RIEGLE. That gets directly to the heart of the matter, because I think there is a significant gap here. That is that the Commission decided that they would stop short of doing that internal management audit to identify precisely who behaved improperly either the night before the launch and the morning of the launch or over a longer period of time with respect to the gravity of these problems. They apparently did so in terms of my conversations with Secretary Rogers on the theory that you folks would do that, that would be your job.

What I am hearing as I listen carefully to everything that is being said is that NASA is in effect saying, well, we are not really sure that is our job, that the Commission really did the work of going ahead and examining these things. Now our job is to fix the mechanical problems and the other system problems, management system problems, and go on from there.

It seems to me that that leaves out a critically important piece of the puzzle, and that is individuals in critical positions who did not do what they were supposed to do, who behaved improperly, who did not follow the established procedures with respect to communication at a minimum and it seems to me with judgment, in addition to that, in terms of just the qualitative judgment under the circumstances.

I guess what I am waiting to hear from you is the Commission, it seems to me, has left that problem with you to solve but that does not mean it is to sort of fade away. It seems to me it is there with a very precise requirement on your part to act affirmatively to identify the people who were in the decision process and in fact to take them out of the decision process unmistakeably for the future.

Now, that is this Senator's judgment.

Dr. FLETCHER. Senator Riegle, I think your observation is absolutely correct. It is our responsibility to deal with the individuals involved and also with the errors in the system that may come out.

People had put together a system and apparently procedures and communications which apparently had defects in it. Those people that designed that procedure also have to be dealt with. It is dealt with, however, not in our normal way. This is a serious accident, but it will be done very carefully.

What we are telling you is two things. One is that in the future individuals that have a sense of responsibility for making correct decisions and following procedures and communicating properly will be put in those line positions. That is the first point.

The other point that I tried to make clear is that with regard to the people that were making faulty judgments, that will be taken into account in terms of their future positions within NASA. We are doing that.

Senator RIEGLE. Who is responsible for that part of the effort to see that that analysis is being done, as painful as it is? That is an awful chore, but it is a vital chore and I am wondering who has that assignment.

Dr. FLETCHER. Ultimately, it will be myself, Senator Riegle, but I will not do so, of course, without the consultation of Admiral Truly and also the Center directors who were involved. Even they are not in the line of command, the people in a reporting sense who report to the various Center directors will also be involved in that process, the Center directors being Marshall Space Flight Center, the Johnson Space Center, and the Kennedy Space Center.

Senator RIEGLE. Beneath you is any individual, and you have a lot of things to do, and it is a terribly complicated job at the moment, is there anybody beneath you that has been given a specific assignment in this area to tie up the loose ends and to get this part of the job done with care and completeness?

Dr. FLETCHER. I do not think there is an individual so designated. We do, Senator Riegle—it is primarily in discussions between myself and Admiral Truly and also Dr. Graham, who was here at the time. Those three individuals primarily are dealing with it, but also with our personnel procedures. We have to be careful we follow the rules, as you know, with the civil service system.

Senator RIEGLE. Well, I understand that, and one of the reasons we have had this accident is, we did not follow the rules, and the people that did not follow the rules, it seems to me, have to be identified, and there has to be a response here. And I say that because I think that is not typical within NASA. That is atypical. I mean, we have had a splendid record of success over decades now because people have performed to a higher standard than that, and I do not want that standard compromised, and I do not want the situation to happen of this magnitude where people perform at a standard far below that, and then somehow or another that gets sort of washed out here. And that there is any notion on anybody's part that that is acceptable or that that is the way NASA as a whole operates, it cannot. It should not.

I am confident with you and Admiral Truly that it will not. One of the ways you make that clear is that you, just as a surgeon would and with a surgeon's care, I think that problem has got to be addressed from A to Z, and every single person that did not behave and function properly has got to be identified, and there has to be some kind of disciplinary action taken here.

Dr. FLETCHER. Well, certainly what you say will be done, and is in the process of being done.

Senator RIEGLE. Do you have a role in that, Admiral Truly, as such?

Admiral TRULY. Yes, sir; I do. In the civil service system the various performance reports for all the senior people at the Centers come through me, and then on procedurally through a performance review board. And I can personally assure you that Dr. Fletcher and I have discussed this, and potential future reassignments or jobs for many people, and some have happened, and some are still under discussion.

Senator RIEGLE. At any time in the future will we be able to get a summary report from you as to what has happened in this area so that we are clear that that work has been done?

Dr. FLETCHER. Senator Riegle, I think we will be happy to do that at some time in the future. I do not know what time, at the present time, but speaking for myself, because I am taking the review of

the whole NASA system certainly from my point of view before the end of this calendar year, we will have that information for you. It may be earlier, though, from Admiral Truly's point of view.

Senator RIEGLE. Well, to finish this discussion in this area then, I gather that it is both your feelings that the Commission did leave that job for you to do, and that you fully—and that you see that as a job to do, and that it has been left to you, and that you fully intend to do it. Is that a fair summary?

Dr. FLETCHER. That is my opinion, Senator Riegle.

Senator RIEGLE. Is that your view also, Admiral Truly?

Admiral TRULY. Yes, sir. If that is Dr. Fletcher's opinion, I can assure you that I will support him.

No, seriously, yes, sir.

Senator RIEGLE. Well, I think it is very important, and I think that an awful lot of people that care about that issue and that response, including family members of the astronauts, and a lot of others, and so I think it is a key area. I want to ask one other thing to you, Mr. Lee, and anyone else who might want to comment on it, and that is, as I understand it there is some question as to whether or not the solid rocket boosters were ever properly qualified against the specifications that were laid out in the beginning when we signed the contracts and decided to go ahead. What is the situation there? Were they qualified to the specifications or not?

Mr. LEE. The answer is in the form of qualification tests, no, and if I could give a little explanation, and I will try to be brief. There are a number of ways that you can qualify or that a contractor can in fact qualify the specifications that could be done by development test, qualification test, or by analyses, and usually throughout a program, the contractor will use all of these in the process of satisfying the specifications imposed upon them.

The specification which requires the full range of environmental conditions for the solid rocket motor to be qualified to, if you will, or certified to, has to do with the induced temperature, induced environment for temperature on the motor, which ranges from 26 degrees Fahrenheit to about 120 degrees Fahrenheit. Those requirements were in fact imposed on the contract and Thiokol chose to certify the joint through those extremes by analyses.

In our review with the Commission, and that is under the production and development team headed by Mr. Joe Sutter of Boeing, when questioned on this, the Thiokol response was that they had misinterpreted that requirement not to be a vertical flight requirement but a storage requirement. Therefore, they did not conclude on their part that they had in fact certified to those limits even though the agreement between the Thiokol and NASA was that to certify that particular area. The environment would be certified by analyses.

The acceptance on the part of NASA was based on the specification of the O-ring material itself, which was identified to be good through the range of minus 30 degrees Fahrenheit to 500 degrees Fahrenheit. Now, this was the basis for which the NASA accepted that certification. However, in reality Thiokol did not conclude that they interpreted that requirement to be of that range. Therefore they did not stand behind, if you will, the fact that they had certi-

fied for vertical flight or were required to certify for vertical flight through those ranges.

Senator RIEGLE. Well, as I listen to that, the bottom line is that it was not properly certified. Is that correct?

Mr. LEE. Yes, sir; I believe it was not properly certified.

Senator RIEGLE. Now, to what extent is that NASA's fault, that there was this mixup in communication or whatever, and the fact that the certification was not done as it should have been?

Mr. LEE. Under consideration, in hindsight, obviously what we know today about the joint, I would say that the first agreement to certify that critical joint by analyses was improper and inadequate, and the fact that because I would say today we should have specified that it be tested through those environments, and the second part of——

Senator RIEGLE. When you say we, you mean NASA should have done that?

Mr. LEE. Yes, we in agreement with the contractor. Now, the second part, that is also inadequate on the basis of what was in fact agreed to is that the review or the acceptance of a mil spec which for only the O-ring for that range of temperatures in my opinion was inadequate even for analsyis, but that was in fact what NASA used.

Senator RIEGLE. Now, when that kind of discussion and engineering work and talk goes back and forth, is it principally between or was it principally between the Huntsville Center and Thiokol in this case? Is that principally where this happens?

Mr. LEE. Yes, sir.

Senator RIEGLE. So to the extent that NASA did not follow through with the kind of full blown certification that they should have, would that have been principally the responsibility of the Marshall Center?

Mr. LEE. Yes, sir.

Senator RIEGLE. How high up the line are these things monitored at the higher levels of management within NASA? Should the people at level 1, for example, have been aware of this? Or only if it were brought to their attention?

Mr. LEE. That responsibility, I believe is throughout the agency. For the establishment of requirements, the end item specification, if you will, on a project resides within the project office, whether that is Marshall or JSC, for the orbiter or what have you. It is, in fact, the responsibility in this case, and it was, of the project manager ultimately to approve or accept that certification.

Senator RIEGLE. And who would that have been at the time?

Mr. LEE. At the time I believe that was Mr. George Hardy.

Senator RIEGLE. And he would have had the authority by himself to basically accept something short of a full-blown certification?

Mr. LEE. Not entirely by himself. He has the benefit of our technical review individuals within our center and our quality organization.

Senator RIEGLE. But those other signoff individuals would have been at the same level?

Mr. LEE. In essence, yes.

Senator RIEGLE. It would not have been pushed up to level 2 or level 1?

Mr. LEE. Not for that approval.

Senator RIEGLE. Do you think that is sound?

Mr. LEE. I believe under the place where it was inadequate was the initial establishment of the requirement. Had we required that it be qualified in tests through that range, we would have identified a lot of the shortcomings of the design and our knowledge of the design and the function of that joint would have been well known to us and established a data base which could have been used throughout the operation.

Senator RIEGLE. I want to come back to one other thing, and then we will finish here, because the hour is late.

I want to come back to this issue of responsibility up the line and not just down the line. Mr. Weeks took part in this review about the seriousness of the O-ring problem, this presentation that took place in August of last year. I want to understand again clearly. Once he was aware of the gravity of that problem, where his responsibility would have required him to report that information, where would he have been expected to convey that information to once he had it?

Dr. FLETCHER. Senator Riegle, I cannot speak for Mike Weeks, who is not here, but normally if Mike had thought this was a serious problem enough so that we should call a halt to the program until we fixed it, he would have relayed that on to level 2, which is Mr. Aldrich, but also up to the administrator, because that is a pretty serious thing; of course, also to Jess Moore, who he reported directly to. It really is a judgment question. Did he and his colleagues feel that this was a serious enough problem to call a halt to the program? Apparently Mr. Weeks in discussions with myself and others felt that this was a serious problem but not serious enough to relay up and down the line as he in retrospect should have.

Senator RIEGLE. Within the last year or two would there have been other meetings of that kind on other problems that would have bubbled up to the top with that level of gravity that would have brought about a special meeting of that kind in Washington?

Dr. FLETCHER. Senator Riegle, I am not sure you have the right people to answer that. This is my fifth week, and I think it is Admiral Truly's fifth month.

Senator RIEGLE. Maybe Mr. Aldrich would know, and if not I will address the question to others. Might you know?

Mr. ALDRICH. Well, I believe there was a regular pattern of reporting up the channels normally through level 2 to level 1 and to the administrator on critical problems. An example are the orbiter brakes and the landing system which have been troublesome for a number of flights and a number of years. We have attempted very strongly in the program to find corrective actions and to get all people involved and all outside help we could get to solve those problems, but they continued to plague us. On a number of occasions, we reported the technical status and planning in those areas all the way up through level 1 and to the prior administrator.

Senator RIEGLE. Within roughly, say, the year prior to the accident, were there any meetings that would have been the equivalent of this where criticality 1 items were brought to the Washington level for a special meeting because of their gravity?

Mr. ALDRICH. Well, I will give you two answers. One, portions of the landing system are criticality 1 items, and I discussed those. I am certain there would be other meetings also, probably on the main engines, but I cannot give you a specific example without researching it.

[The following information was subsequently received for the record:]

ISSUES PRESENTED TO NASA HEADQUARTERS PERSONNEL

1. SOLID ROCKET BOOSTERS

A. Problem: New Burn Through of the Nozzle Ablative Material on STS-8.

Presented To: 1. Mr. Beggs, Dr. Mark, Gen. Abrahams on, Mr. Weeks—September 1983.

2. Gen. Abrahamson, W, Dankhoff at Morton Thiokol, Inc. (MTI) on October 7-8, 1983—overall SRM status report, emphasis on nozzle issues.

3. SRM Program Review, July 26, 1984.

4. Special SRM Nozzle Review at MTI April 2, 1984 TWR # 14324.

5. STS-9 FRR/Flight Worthiness Review at Headquarters November 2, 1983.

Purpose of Presentation: To review ablative material erosion on STS-8 left hand solid rocket motor nozzle. The remaining material would support a nine second additional burn time. Results of comparison with previous flights and tests, material, cure cycles and methods of illeviating erosion problems etc., were presented. Flight worthiness of STS-9 was approved.

2. SPACE SHUTTLE MAIN ENGINES

A. Problem: Engine 2109 Main Injector Failure.

Presented to: Mr. Beggs at NASA Headquarters—August 10, 1981.

Purpose of Presentation: To summarize the failure investigation results of ground test of Engine 2108 main injector failure, background of prior similar failures, corrective redesign and substantiation that current design with reduced life is safe to fly prior to incorporation of redesign into flight engines.

B. Problem: Engine 2005 High Pressure Fuel Pump Impeller Failure.

Presented To: Mr. Beggs and Dr. Mark at NASA Headquarters August 27, 1982 and Dr. Mark at NASA Headquarters October 18, 1982.

Purpose of Presentation: August 27, 1982 Presentation—to report results of Engine 2005 high pressure fuel pump impeller failure analysis and cause, fuel pump options for STS-5 Mission, and recommendation for continued use of fuel pumps for STS-5. Mr. Beggs approved recommendation. October 18, 1982 Presentation—To present results of worst case impeller failure analyses requested by Dr. Mark to identify effect on fuel pump performance, effect of mechanical vibration on fuel pump parts, and effect on any other element of engine fuel system.

C. Problem: Two Flight Engines Delivered to Field for Flight Use with Discrepancies not Detected During Engine Acceptance Process.

Presented To: Mr. Beggs at NASA Headquarters—February 22, 1983.

Purpose of Presentation: To explain why Engine 2011 combustion chamber outlet neck cracked and why Engine 2016 LOX heat exchanger tube leaked, how these two discrepancies escaped detection during engine acceptance testing and checkout prior to shipment to field and what confidence does MSFC have that these or related problems do not exist on other flight engines, and what measures are being taken to assure no reoccurrence of this problem.

D. Problem: HPFTP Second Stage Turbine Blade Cracks.

Presented To: Mr. Beggs and Dr. Mark at NASA Headquarters—March 30, 1983.

Purpose of Presentation: During STS-6 FRR, data was presented on HPFTP second stage turbine blade crack experience/test history with recommendations rationale that STS-6 HPFTP's were acceptable to fly. During the FRR, an action was assigned MSFC to provide a more detailed briefing prior to STS-6 flight on blade cracking that had been observed in several HPFTP's. Based on the additional data presented, it was concluded that there was a high probability that STS-6's HPFTPs have no cracked blades and a small probability that cracks could initiate during STS-6 engine flight operation and based on engine test history, there was high confidence that a crack would not propagate to failure.

E. Problem: STS-6 Engine Flight Discrepancies Applicable to STS-7.

Presented To: Mr. Beggs at NASA Headquarters—May 19, 1983.

Purpose of Presentation: To identify engine discrepancies that occurred during STS-6 flight and corrective action taken to preclude re-occurrence on STS-7.

F. Problem: HPFTP Turbine Sheet Metal Cracking.

Presented To: Dr. Mark by telecon June 6, 1983.

Purpose of Presentation: To delineate the history of HPFTP turbine sheet metal cracking, inspection methods to find cracks, crack acceptance criteria, crack repair procedures, and long range design and fabrication procedures to correct.

G. Problem: During Columbia Engine overhaul, re-X-Ray of main combustion chamber inlet line indicated thinner walls adjacent to welds and greater weld offsets that used in stress analysis.

Presented To: Dr. Mark at NASA Headquarters—July 29, 1983.

Purpose of Presentation: To present results of inspections make on all flight and ground test engines to determine condition of welds on MCC inlet lines, results of stress analysis on line life using inspection data and special lab tests to determine strain vs. load on line welded parts, and rationale for recommending Challenger ok to fly (STS-8).

H. Problem: HPFTP Coolant Liner Overpressure Results in CRIT 1 Failure.

Presented To: Dr. Mark by telecon on March 29, 1984.

Purpose of Presentation: To summarize the failure investigation results of ground tests of Engine 0108 that demonstrated HPFTP coolant overpressure was not a self-contained engine failure, that the exact cause of Engine 0108's failure was not fully determined, and that a coolant liner pressure redline was developed, tested, validated, and that implementation was mandatory for STS 41-C.

I. Problem: HPFTP Temperature Redline Sensor Failures.

Presented To: Mr. Yardley at NASA Headquarters—August 8, 1985.

Purpose of Presentation: To report the results of the failure investigation related to HPFTP turbine temperature redline sensor failures that cause premature safe engine shutdown during STS 51-F, changes to temperature sensors design and manufacture, and redline implementation prior to subsequent flights.

3. ORBITER BRAKES

A. Problem: History of Brake Damage on Landing.

Presented To: Mr. Beggs on May 15, 1985.

Purpose of Presentation: Review of brake damage history and recommendations from first meeting of Industry Ad Hoc Brake Committee. Showed recommendations were in work. Approval was obtained to continue with the brake upgrade program including implementation of the stiff axle to reduce brake damage, augmentation of the brake flight instrumentation, improving the nosewheel steering system to offload the brakes and the reinitiation of brake studies based on the use of structural carbon in lieu of beryllium.

B. Problem: Review of Ad Hoc Brake Committee Recommendations.

Presented To: Mr. Jesse Moore on December 6, 1985.

Purpose of Presentation: The recommendations from the second meeting of the Ad Hoc Brake Committee were reviewed. These recommendations, which had been implemented, included activation of nosewheel steering as the primary mode of directional control, performing near term testing on the pitch plane simulator and installing brake housing orifices. The results of the structural carbon brake studies were presented with a recommendation by JSC that carbon brakes be procured for the Orbiter. The Associate Administrator for Space Flight approved this recommendation and authority to proceed was issued December 16, 1985.

Senator RIEGLE. I would appreciate it, Dr. Fletcher, if the right person who can dig that out would do so so that we would have a sense for whether there were other meetings that would truly be equivalent to the gravity of the meeting that was held in August on the O-rings related to other items that were criticality 1 and where the red flags were really up that said we have got a serious problem here and one serious enough that it requires a very high-level Washington based meeting.

Dr. FLETCHER. Senator Riegle, we will do our best, recognizing that some of the people that were involved in those decisions have left, but I think there are enough people around and we can do a pretty good job on that problem for you.

Senator RIEGLE. I have one other question. Then I will finish. And you are correct in noting that you and Admiral Truly are new in your assignments, and so that you could speak knowledgeably about what you have done and seen since you have been there but not so much before that. I continue to be distressed and disturbed by how difficult it has been to get information out of the Huntsville Center since the accident. There was a long delay in even finding out about the big argument that took place the night before the launch. There has been an anonymous letter sent by one of the senior engineers down there.

He is a senior manager, unidentified, but sent a very detailed letter, I gather, to the Rogers Commission, and I just had access to this letter yesterday signed with the pen name Apocalypse, but talking at great length here about major problems within the Huntsville Center and information being withheld deliberately, that there was a conscious effort made after the accident to give out as little factual background information to the Commission as possible, a very serious charge, and I do not know whether more will come of this letter or not in terms of this individual perhaps coming forward.

I would hope they would come forward, and I would hope they would come forward in a personal way, and not just by means of an anonymous letter, but then just the other day there was a video tape as I understand it, and I have not seen it, of the part of the warning or the presentation on the O-rings that was just suddenly discovered, and this, of course, after the Commission had finished its work and published its report, and you sort of scratch your head and you say to yourself, is that not strange that something as fundamental as that would be there as a factual record right on the problem of the O-rings, and yet remarkably nobody seemed to find it or nobody seemed to volunteer and bring it forward and so forth.

I guess what I am saying is this. It seems to me there was a pattern—it may still be continuing—of less than a full and affirmative bringing forth of information out of the Huntsville Center. I have just cited some of the examples, but there are others that you are familiar with, some of which we have discussed previously, but I am wondering. I want to register my strong feeling about that, and I want to ask you to comment on it, and what steps are being taken to deal with that problem, which seems to me to be more than a problem of just an individual. It seems to me something that is broader than that, and I think it has to be cleaned up once and for all, and I would like to hear your comments on it.

Dr. FLETCHER. Senator Riegle, there are two points that I think ought to be made. One, the specific instance that you mentioned about the tape that was found later, and I would like Admiral Truly to address that in a minute, with regard to the generic problem, if you like, and that is the seeming reluctance for the Marshall Space Flight Center, and it was singled out in the Commission report to communicate to other centers and to headquarters.

Senator RIEGLE. And to the Commission.

Dr. FLETCHER. And to the Commission. That is the purpose of the General Phillips task force; to flesh all of that out and make sure that communications are tightened up between centers and between centers and headquarters so that we really manage our programs much better than we have in the past or than we ever have. I hope by the end of this year we will have some good answers as to how we fix that.

Having said that, we do not have all the answers now. I am not sure that there are not a lot of other problems lying around. We are taking this time now that we are down, to fix the seals and those other technical fixes. Admiral Truly is going to tighten up his management and his shop. While we are doing that, I thought we might as well take a look at the whole NASA Program, how the centers operate, which ones are a little faulty, if that is the case, which ones need improvement, how do we change management, and so on and so forth. How do we manage our programs that we are doing very intensively during the next several months.

Senator RIEGLE. You were going to comment, Admiral Truly, about this tape presentation that just recently came to light.

Admiral TRULY. Yes, sir. I am very glad you brought up this point, because it is one that over the past months I have been in many conversations with other people, including some animated conversations with the Commission during the course of the investigation. Without defending any specific instance, I must tell you that during the investigation, and working primarily with Jack Lee who is the Deputy Director of Marshall Space Flight Center, I never, I personally as head of the task force, never ran into a single instance where I personally felt that I was not getting information through me to the Commission as requested and as quickly as possible.

I am delighted you brought up this situation with this video tape because it is specifically one that Mr. Lee and I personally worked, if I may, I would like for him to describe for you the background of that video tape at Marshall. I can assure you that when the phone call came up to me concerning that video tape, within 10 minutes the Commission knew that it was in existence, and within 12 hours, which was what it took to get the people at work to do it, we had transmitted the video tape via satellite through Goddard to here, and it was in their hands.

With your permission, I would like for Mr. Lee to mention the situation at the Marshall Center, because I think it is a crucial one.

Senator RIEGLE. Well, I am going to do that, and I would like to hear his response before I do. In terms of just putting it at a point in time, you got that tape what, 2 weeks ago, or 10 days ago or thereabouts?

Admiral TRULY. It was the week it came to my attention the week before the Commission—it was in the middle of the week before the Commission was to release its report.

Senator RIEGLE. Certainly several months after the accident. I mean, for reasons that we are going to hear from Mr. Lee, but I am not surprised that you would get that tape to the Commission within 10 minutes, because that is the kind of person you are. What I am concerned about is that it did not get to you for the better part of 4 or 5 months.

Admiral TRULY. That is what I would like Mr. Lee to address. As a matter of fact, I am very sorry that it would not have, because it would have been very much to the benefit of the Marshall Space Flight Center and the Commission and the task force to have had it. It did add a face and words describing the problem that before were only vu-graphs.

Senator RIEGLE. Or people's recollections.

Admiral TRULY. And that image would have been very important to the Commission and to us as we did it.

Senator RIEGLE. Mr. Lee.

Mr. LEE. It was on May 29 or 30, in that time period, when at headquarters, some representatives from the Marshall Space Flight Center and JSC were reviewing with the House staff group in support of their investigation of the accident, it was mentioned by one of the staff members that they had either heard or thought they had heard a tape of the flight readiness review.

That triggered the individual representative from Marshall to ask the question about that, such a recording, because we were not aware that they were in fact recorded. But the fact that that came up and the fact that we are in fact sensitive to information, because of the Commission's statements—as you have made, in providing information, they inquired of our flight readiness review process about, at Marshall, if such tapes—if such flight readiness reviews had in fact been taped.

Now, you have to go back in time. When General Abrahamson was the AA, he started the process of video teleconferencing flight readiness reviews. And when asked about the recordings, our communications office at Marshall, which coordinates these video conferences, acknowledged that they had in fact recorded at least four of these flight readiness reviews, primarily for the purpose of working out quality problems in the transmission.

We would transmit the video over one line and the audio over another line, plus the production itself really was not adequate itself to everybody's satisfaction.

There was no requirement on the part of level I, level II, or level III at Marshall Space Flight Center to record these. In fact, no one knew until this time that they had in fact been recorded. They were only recorded to work out the quality of the transmission itself.

That was on the 29th. On the 3rd of June, I was notified by our communications manager that he had been requested for information for these tapes for the benefit of—of flight readiness reviews, for the benefit of the Commission, and wanted to know what he should do with them.

I said, well, first you retain them. Let us review the tape to see if there is pertinent information on these tapes. And it was determined that, specifically about the O-ring now, it was determined in one of these tapes Mr. Mulloy did in fact give quite a 2½-minute dissertation on O-ring erosion and the history thereof.

I immediately called Admiral Truly's office to notify him of the situation. We in fact played the tape through the transmission loop, the communications loop, to headquarters. On the 4th, I notified Mr. Thompson's office, which is my route for getting information to the Commission.

And on the 5th of June, I had hand delivered that set of tapes to Mr. Thompson at KSC. So there was no way that we knew that these were even in the system. They were not a part of any program. I did exactly what I was expected to do when I identified or uncovered information which might be pertinent to this Commission.

Senator RIEGLE. Well, it is good to have that story on the record. I am not going to ask for the answer as to why it took so long for the knowledge of the argument before the launch to come to the attention of the Commission, but it sure took a long time and I do not think there is any excuse for it.

And I just want to make my point this way, because there are lots of other instances of this kind that could be cited, whether it is one reason or another given for why it was, that we did not know we had this, or this came to our attention late, or we did not think anybody wanted this, or we thought somebody else was going to give you that, or well, nobody asked us and so we did not volunteer it, and so forth.

And if there were not a pattern over a long period of time of a lot of information coming very slowly, very grudgingly, very much in a piecemeal fashion, then I think you could take a single instance in a different context. But when there is that context over a long period of time, it is a problem, and I think it is seen by many people as a problem and I think it is seen by the Presidential Commission as a problem, and I think they have made that clear at different points themselves.

I guess what I am interested in now is, I want to know whether you, Dr. Fletcher, or you, Admiral Truly, have said in plain language to the people at Marshall, I mean to everybody at Marshall, we want every last scrap of information that relates to this, and whether it is damaging to somebody else, to a superior, or to somebody that is a work associate; we want the full truth, we want every single shred of information; and that anybody that comes forward with the information is not going to be punished; and that if anybody else makes an effort to punish somebody that comes forward, that they will be out of NASA within 10 minutes, on their ear, civil service requirements or not; that if anybody attempts to carry out any kind of intimidation or reprisal, they are out the door, as they properly should be.

But has that been said in plain, blunt English, in such a way that that message has gone absolutely through the Huntsville Center, so that everybody feels free to come forward with any additional information that they might have?

Admiral TRULY. Shortly after I arrived on the scene and as chairman of the task force, I did personally talk to Dr. Lucas, and I talked to Mr. Lee. And as I said, from my view—and this was a difficult investigation.

In my view, we responded to the Commission throughout that time period, and so did Marshall, as best as we were capable under the situation at hand, with the requests coming in from the Commission, the Congress, the Freedom of Information Act, and so forth.

I agree with you 100 percent, though. The investigation did take the total knowledge, both in paper and in videotapes—although in that case it was an unfortunate case, because had we known it earlier I would have dearly loved to have had that videotape and had knowledge of it 3 months ago. It would have been of great value.

It was not hidden, but you cannot bring forward what you do not know exists.

Senator RIEGLE. Now, when you say that you spoke to Dr. Lucas and you spoke to Mr. Lee, that is fine. But that is not to me the same thing as you personally transmitting the message, either in a large meeting or over a television screen to assembled people in Huntsville, to make it crystal clear that you want every scrap of information and that there is not going to be any kind of intimidation or whatever used.

Now, you are as familiar as I am with a lot of the observations and comments that have been made about Mr. Lucas as a pretty tough, heavyhanded sort of an administrator, who did not like people disagreeing with him very much. And it seems to me that the requirement to make people feel comfortable about coming forward with the facts that they had is something that has to be transmitted broadly.

I mean, you have to get that message out, in a sense, directly to people. And I gather that has not been done, or has it been done?

Dr. FLETCHER. Senator Riegle, I think I want to turn to Jack Lee, who was deputy at Marshall at the time. But the normal way we do this is in two directions.

One is we inform the Director of the Center and we expect him to relay that on to the troops. We did that recently, for example, in terms of our responses to the Rogers Commission report. We told them. Hey, this is a good report; let us be responsive. That went down through the Center Director and I understand was appropriately communicated to the rest of the people at the Center.

Admiral Truly did that with the Center directors and that was, I expect, done, although I will have to ask Mr. Lee to address that.

The other way is the way you suggest. Occasionally we do address the troops by way of, we call it, closed-circuit TV, but it goes via satellite to all of the media as well. But nevertheless, we have that mechanism for informing the troops.

In this particular case, I do not know that that second was followed out, and I am not sure it was required. I would guess that you ought to ask Mr. Lee about the communications downward from his office.

Senator RIEGLE. Well, before I do that, I am much more concerned about the communications downward from your office and from Admiral Truly's office, because you are the fellows that really run the show and that is who I think people are going to take their guidance from.

Now, Mr. Lee and Mr. Lucas were key players in Huntsville, and obviously people there are going to take their signals from them. But we have had instances now where information has been forthcoming, in a sense, around that management structure at Huntsville, and I think there is probably more information there that people might want to contribute. Maybe it is material, maybe it is not.

But I do not think that is easy to do unless there is a very strong signal from up top, namely from the two of you, that says: Look, we want to know everything there is to know, and we are not going to allow any reprisals to take place against anybody, and that is just the nature of the situation.

And it is an unmistakable signal so that senior management types are not in a situation where they are sending anonymous memorandums. I do not think they should have to do that. And for one thing, I would hope that you would use that television net and that you specifically would say to this individual and to any others like this person. We expect you to come forward, we want you to come forward, it is not going to be held against you if you do.

Dr. FLETCHER. Senator Riegle, I think I agree with you. And I came in kind of late in the program, and I was tempted to do just that. I prefer to do it in person and I plan to do that at Marshall at the earliest opportunity.

As soon as I can get some decisions out of the Congress and the White House, I plan to go to Marshall—Marshall is first on my list—to discuss just that. I imagine the same is true of Admiral Truly, as soon as he gets some time to do it.

Senator RIEGLE. So it is your intention to say that directly and personally to the people in Huntsville?

Dr. FLETCHER. Yes, indeed.

Senator RIEGLE. And some time quite soon?

Dr. FLETCHER. Yes. Rather than over the net, to talk to them personally, yes.

Senator RIEGLE. And I take it you agree with that, Admiral Truly?

Admiral TRULY. Yes; I certainly do. And as a matter of fact, I wish we had had this discussion a little earlier, because I did get on television to all, not just to Marshall Space Flight Center but to all of the NASA centers, shortly after I came, when I laid out our strategy for returning to safe flight.

On that occasion, I was looking forward, and talking not only to Marshall, but to Johnson, Kennedy, and so forth, and that would have been a beautiful opportunity for me to do just what you said. And I made, looking back and after listening to your suggestion, I made the mistake of missing such an opportunity. I assumed, which is a very bad thing to do in this sort of business, that it was not necessary since I felt like what I said and the way I said it would make it obvious.

But now that I look back, I wish I had said it the way you put it, because it is absolutely true.

Senator RIEGLE. Well, you still can. And I think it will help, and I gather you intend to.

Admiral TRULY. I certainly do. And I hope it will—I hope we are over the point where either the Commission or the task force or NASA or any of us can communicate through anonymous letters, because I cannot respond that way, as you know.

Senator RIEGLE. Exactly, and people should not have to. And that is why I hope the individual who wrote this letter will, in light of the climate that you are putting forward here today of openness, feel that they can come forward because that is properly what they should do, and I think they owe it to themselves and to the system and to the astronauts that were lost and everything else.

My last point is this. We have talked before, and we did the other day at the White House when the Commission's report was forthcoming, about the desirability of perhaps setting up an ad hoc group, perhaps just through the end of the year, maybe just through the end of this legislative session, that would include the

appropriate key figures in Congress who have responsibility for space authorization and appropriation, presumably the two of you, and whoever the two or three or whatever number of people in the executive branch; and that this small group of people who have to try to work through these decisions here in a legislative session that is in the process of winding itself up, that we would have a chance to sit down around a table and maybe expedite some of the discussion and some of the effort to reach a consensus that is needed, so that we can decide what we are going to do and how we are going to do it and in fact get it done, get it done this year.

I am concerned that we are caught. We are still behind the curve in the sense of other events, the normal legislative calendar here and the other items on the schedule, the fact that we are having a hard time apparently with these policy judgments in the executive branch, and we have got divided jurisdictions here in the Congress.

And you have got enough players at work that it is very easy for the time to slip on by here, and all of a sudden we will be next year and we will not have done things this year that we might have.

I have spoken with Chairman Gorton about attempting to see if we cannot get that kind of an ad hoc mechanism in place on a one-time basis. It is not to try and proliferate bureaucracy. It is to try and overcome bureaucracy.

It is to try and allow us a way, if we could meet once or twice a week, at least enough times to try to decide where we are and where we are going, that we can get our work done before the Congress adjourns this year, and that all of the players could fit together as a team.

And after all, we ought to be a team. We are all trying to accomplish the same goals. And I am just wondering if, from your vantage point, if you feel that that kind of an arrangement, if we could get it put together, would be helpful to you in perhaps resolving some of these items or moving them along a little faster.

Dr. FLETCHER. Senator Riegle, as you know, I enthusiastically embraced it. I had not realized you had talked to Admiral Truly, but we had discussions afterwards. We think it is an excellent idea and it should be implemented as soon as you can. We are ready to go ahead with that procedure.

Senator RIEGLE. Well, we are going to try to. Senator Gorton and I discussed it today, and I do not know how the administration will feel about it. It is only a desire to try to be helpful to the process, so that we can make decisions sooner rather than later, and to get some kind of a consensus as quickly as we can.

So in any event, we will try to pursue that, because we want to be helpful to you. And I hope you know that from the other meetings and sessions and work that we have all done together, and that it is essential that we get the space program running again.

And I appreciate the work that both of you are doing in terms of the extraordinary duties and responsibilities you have, which are new to both of you and which I feel you are working as hard at as you can. And I hope that you will understand that the concerns I think expressed by everybody on the subcommittee here today are concerns that are aimed exactly in the same direction.

In other words, we want to get things fixed properly so that we can get back into space safely and get back on with the goals that we have to meet as a nation, and hopefully we will.

And I appreciate your testimony today, all of you.

The committee is in recess.

[Whereupon, at 12:45 p.m., the subcommittee was recessed.]

[The following information was subsequently received for the record:]

Questions of Senator Gorton and the Answers of Dr. Fletcher

Solid Rocket Motor Redesign

Question 1: One of the Commission's recommendations in support of the Solid Rocket Motor redesign is to consider static firings of the exact flight configuration in a vertical attitude. In what ways is a vertical test better than a horizontal test and are there problems uniquely associated with a vertical test?

Answer 1: An assessment of the SRM static firing orientation that is most suitable for accomplishing the objective of verifying the SRM operational capability at load conditions induced during launch and flight is in progress. The assessment is scheduled for completion by mid July 1986. Major factors under study include:

1. Ability to simulate launch and flight limit loads.
2. Ability to simulate launch and flight joint dynamics.
3. Nozzle up or nozzle down attitude.
4. Availability of facilities (schedule).
5. Cost.

More specifically, the advantages of a nozzle-down vertical attitude static test are that it places the propellant, insulation, and other elastomeric materials in the proper flight orientation under normal conditions. Assembly (mating) would be accomplished using the prelaunch procedural method. Problems uniquely associated with vertical test deal with facility protection, holddown structural configuration, slag accumulation, flight loads replication, and environmental impact of exhaust particularly if flame deflection must be water cooled.

Question 2: I understand that one problem associated with testing in a vertical attitude is determining whether the test should be conducted with the nozzle up or down. What are the considerations for testing in both vertical positions?

Answer 2: The considerations for vertical static testing are:

a. Nozzle up - It is questionable if the forward SRM structure can withstand the weight of motor and the motor thrust load. Slag accumulation in the forward dome will probably necessitate additional insulation thickness and there is concern with the insulation stress relief flap structural integrity in this reversed configuration.

b. Nozzle down - It is extremely difficult to accurately understand motor performance due to the necessity to analytically derive net performance as a function of measured thrust and propellant consumed. The facility considerations involve flame deflector cooling particularly with water that produces acid rain and the ability to absorb thrust loads approximately 200 ft. up the test stand structure.

c. Either attitude - Feasibility to reasonably introduce or simulate flight loads and deflections of the SRM is doubtful.

Question 3: What facilities, either at NASA or elsewhere, exist for a full-scale vertical test of the Solid Rocket Motor?

What would it cost and how long would it take to develop such a facility and to qualify a new SRM joint design?

Answer 3.: No facilities exist at NASA or elsewhere to perform a full-scale vertical test of the SRM. A number of large motor vertical test facilities can be modified to accommodate the Space Shuttle SRM. These include facilities at the Air Force Rocket Propulsion Lab, National Space Technology Laboratories, Kennedy Space Center, and the Marshall Space Flight Center.

Answer 3: Based upon early assessments, it is estimated that a vertical test facility could be available in 15 to 18 months at a cost of $15 - $20 million.

Question 4: I understand that transportation of the Solid Rocket Motor segments over long distances has the potential for adversely affecting the performance of the motor. What can be done to prevent any distortion or deformation of fuel segments if they must be transported over long highway distances?

Answer 4: Distortion or deformation of fuel segments during long distance transportation does not adversely affect the propulsion performance of the SRMs. Any distortion in the SRM segments that may affect assembly and/or flight operations can be corrected or alleviated to acceptable conditions by use of special tooling. The objective for the redesigned joint is to make it insensitive to transportation and handling induced conditions and assembly procedures.

Question 5: In addition to transportation and handling, the Rogers Commission has identified other factors, such as environmental effects and flight and water impact loads to which the SRM joints should be insensitive. Of the factors mentioned by the Commission, which will be the most troublesome to develop an insensitivity to?

Answer 5: Analysis of design concepts currently under study indicates that making the joint integrity insensitive to internal case operating pressure will be most difficult. The case joint deflections produced by the internal motor pressure must be controlled to produce minimal sealing configuration changes. This is necessary to ensure that a reproducible, completely understood seal is verified and maintained throughout the SRM operation.

Shuttle Program Management

Question 6: One of the recommendations of the Rogers Commission was essentially to centralize more of the Shuttle Program activities within your office of the National Space Transportation System.

In your opinion, what problems have developed as a result of a "decentralization" of this office, and what ideas do you have on how to improve the function of this office?

What institutional resistance do you expect in attempting to recentralize the function of this office?

Answer 6: As the Commission report stated, the current Shuttle management structure has made the various program element and project managers feel more accountable to their Center management than to the Shuttle program organization. This resulted in inadequate communication throughout the Shuttle organization as to the seriousness of the SRM O-ring problem. Capt. Crippen has been assigned to lead a fact-finding group to address this concern and propose a solution to correct it.

Answer 6: None. The Agency, including the Centers and the Shuttle program, are committed to correcting the problem.

Question 7: I understand that astronaut Bob Crippen has just been asked to study the overall Shuttle program management structure.

Could you elaborate on this effort -- What is the scope of this task, and when will this study be complete?

What areas in the Shuttle program management structure have you already identified as warranting priority consideration?

Answer 7: Capt. Crippen has been assigned to lead a fact-finding group to address the Commission's recommendations II and V dealing with Shuttle management structure, astronauts in management, a Shuttle safety panel, and improved communications. The group will execute this by careful review of the report, interviews with all levels of management (programmatic and institutional), and interviews with knowledgeable people external to the Agency. A report is due in early August.

Answer 7: All of the specific concerns raised by the Commission will be addressed. The short time period provided to the group to complete the review is intended to expedite the entire process.

Question 8: How, and in what capacities do you believe that astronauts can most effectively serve in agency management positions?

Answer 8: The group will seek means to identify positions that may best be served by individuals with the unique qualifications of an astronaut. It will also identify ways to facilitate and promote such position changes.

Question 9: A finding of the Data and Design Analysis Task Force's Development and Production Team is that Rockwell is not sufficiently involved in orbiter processing and launch operations. Could you elaborate on this and please tell us if it was NASA's responsibility, in part, to increase Rockwell's involvement in these activities?

Answer 9: A decision was made by the Agency to consolidate the vehicle processing and launch operations activity under a single contractor in lieu of having involvement by each of the design contractors as was done in previous programs and in the early phase of the Shuttle program. The consolidated effort is entitled the Shuttle Processing Contractor (SPC) and is performed by Lockheed. The SPC was effected in February 1984. Rockwell International continues to provide field engineering, logistics, and configuration management support. The field engineering effort serves as an interface between the SPC and the design organization. This effort provides support for problem resolution, interprets drawings and specifications, supports major tests, coordinates design changes, and transmits the company's requirements regarding waiver acceptance, material review board actions, and anomalies to the SPC and NASA.

The team expressed concern over the separation of the designer/manu-facturing and the operator, in that the SPC may not possess the necessary technical background gained during the design and development phase to adequately determine system degradation resulting from multiple missions.

The roles and responsibilities of both the SPC and design contractors were established by the Agency; therefore, the responsibility for any changes thereto resides with NASA.

Question 10: The review of the Development and Production Team also found that Rockwell was not giving adequate safety emphasis review to the Centaur upper stage and other critical payloads. How has Rockwell been deficient in this regard?

Answer 10: The Orbiter is required to incorporate certain interface and functional modifications (e.g., attach points, fluid and power connectors, etc.) to accommodate payload unique requirements. Some payloads, such as Centaur, are extremely complex and critical. STS/Centaur payload integration activities are conducted in a vigorous and indepth manner, but Rockwell Orbiter, per se, was found not to be fully involved in the payload total integration effort. Rockwell Integration, as the Shuttle integration contractor, does participate in this activity and performs such tasks as conducting analysis to assure interface compatibility and conducting interface safety assessments and hazard analyses. It was the team's conclusion that for critical complex payloads the Orbiter contractor should be a major participant in the payload integration effort to further assure all aspects of safety are addressed both at the element and systems levels.

Communications

Question 11: The Rogers Commission has recommended that in order to improve communications, a policy should be developed which governs the imposition and removal of launch constraints.

Would you explain how launch constraints and waivers were used on the SRB joint seals for the last six Shuttle flights with so few people aware that they were being used -- what flaws in the process permitted this to occur?

What other flaws exist in the present use of launch constraints and their waivers, and how can the use of launch constraints and waivers be improved?

Answer 11: The MSFC Problem Assessment System requires all open problems which are coded Criticality 1, 1R, 2, or 2R to be considered launch constraints and are to be so classified when submitted by the design contractor. Each report is assessed by representatives of the project office, Quality Assurance, the chief engineer and the chairman of the Problem Review Board for correct criticality and constraint assignment. The ultimate authority for establishing a launch constraint resides with the Project Manager.

All launch constraints must be resolved (recurrence control established) or sufficient rationale must exist to conclude that the problem will not occur on the flight vehicle during prelaunch, launch, or flight.

The launch constraints in question were lifted based on rationale for flight readiness developed during the FRR process. Prior to the actual lifting of the constraint, the SRM Project assessed the data and concluded that the hardware was acceptable for flight and carried its assessment to at least one higher level of management in the FRR chain, i.e., the Shuttle Projects Office or Center Board. Once this level concurred with the project's rationale for flight, the constraint was lifted in the Problem Assessment System (PAS), but the problems remained open in the PAS system. The FRR procedures did not require that PAS problems, which had at one time been classified as launch constraints, be carried through all levels of the FRR structure for decision. In hindsight, this may be considered a deficiency, and in the future, it may be appropriate that all items applicable to the launch vehicle in question, which had been classified as launch constraints, both open and closed, be presented to all levels of the FRR structure.

Answer 11: The Problem Reporting and Corrective Action (PRACA) system was established as the means to report all problems into the system. This system has not worked as intended and, in fact, some of the requirements were relaxed in 1981. At that time, it was no longer required that the Level III projects report all problems to the total system (i.e., Level II and I). The requirements for this system are being redefined and rigid reporting standards will be established, especially in relation to Criticality 1 and 1R items. In addition, acceptance of problem closeouts involving criticality 1 and 1R items will be elevated to Level II approval, and it will be mandatory that all criticality 1 problems which have occurred since the last FRR be discussed at the next FRR.

Question 12: How do you think that pre-launch communications for both the Flight Readiness Review and the L-1 Review can be improved?

In the future, what will be done to ensure that Level III problems and concerns receive proper emphasis and attention at Level I reviews?

Answer 12: The Crippen fact-finding group will specifically address the launch decision process. Their objective is to recommend a mechanism to streamline the flow of critical information between Level I, II, and III from the Flight Readiness Review to the final launch countdown.

Critical Items Review

Question 13: What progress to date has been made in the review of Criticality-1 and -1R components -- when will you decide which items require changes or requalification, and what is the likely cost of this whole Critical Items Review activity?

The Rogers Commission has recommended that an Audit Panel of the National Research Council verify the adequacy of this critical items review. Do you agree with this recommendation?

Answer 13: On March 13, 1986, the Manager, NSTS requested that all program failure modes and effects analyses and the critical items lists be re-reviewed for completeness and accuracy. A plan and instructions were provided for implementation. (Reference letter NB/86-L133, enclosure 1).

A technical re-review team with representation from the prime contractors, NASA, and an independent contractor started the reevaluation activities in early April. The team review activity is progressing satisfactorily with KSC reporting 30 percent completion.

Level III project management configuration control board meetings will start in early July for assessment and approval of the technical team findings and recommendations. The technical team review and management approval process will be scheduled on a continuing basis through January 1987 (see enclosure 2 for schedule). When items requiring redesign and requalification are identified, they will receive expeditious processing for approval and implementation. Cost estimates for this reevaluation activity are not available at this time.

Answer 13: Yes. Actions are underway to implement this recommendation.

Landing Safety

Question 14: According to the testimony of Admiral Truly, surface runway testing at Kennedy has already been underway for some time.

What is the nature of this runway testing, and when do you expect to complete it?

How will this testing enhance Kennedy as a landing site?

Answer 14: Kennedy Space Center (KSC) runway testing will not actually be conducted at KSC. Orbiter tires will be subjected to tests at two facilities to determine tire forces and tire wear as affected by Orbiter weight, crosswinds, and landing speed. At Langley Research Center, Virginia, a water jet sled on a 3' X 1800'

test track with KSC runway surface characteristics will be used to obtain tire wear due to spinup and side forces experienced at landing at various landing speeds, crosswinds, and landing weights.

Once spinup effects are determined, dynamometer tests will be conducted at Wright Patterson AFB to examine tire loading and demonstrate tread wear margin.

The test program is expected to be completed by November, 1986.

Answer 14: Potential enhancements at KSC may include painting or smoothing of the runway at the landing area, and/or Orbiter tire tread modifications as determined by a better understanding of tire margins. If the testing supports, relaxation of weight, and landing speed placards could allow more frequent KSC landing operations.

Of primary importance, however, is the determination of tire wear and load margins with respect to both routine and emergency use of the KSC landing facility.

Question 15: According to the Task Force's Mission Planning and Operations Team, current landing and deceleration systems have not shown adequate margins to support routine Kennedy Space Center or trans-Atlantic landings.

In what ways have these systems not shown adequate margins?

In your opinion, what does the future hold for landings at Kennedy Space Center -- do you think it will ever be the primary landing site?

Answer 15: The current Orbiter landing and deceleration systems have not shown adequate margins in the following areas:

1. Possible Tire Failures

Tire wear is excessive for landings on the "all weather" KSC runway surface. The wear occurs in wheel spinup and as a response to crosswinds and is increased when differential braking is used for directional control.

The Orbiter is subject to severe directional control problems if it lands with one main gear tire deflated. Analysis predicts that the second tire (of 2) on the same side will fail at landing, or shortly thereafter because of the increased load it will be forced to carry. Simulator results indicate loss of control (and subsequent loss of vehicle and crew) will occur if the second tire failure occurs at or prior to nosewheel touchdown.

2. Brake Damage

Brake energy is rated as amount of energy available from any one of four brakes. The rated energy is defined by the occurrence of the first stator failure (of three) on a given brake. Early dynamometer tests indicated that 55 million foot-pounds of energy should be available from each brake. Data from three flights has shown that stator failures occurred at or below 42 million foot-pounds of energy using a moderate braking technique. The

available energy is apparently limited by the brake application technique and brake material design. Recent testing using realistic techniques and system pressure has confirmed the flight data.

Other less severe brake damage may occur if the brake pressure is momentarily relaxed during the braking profile. In addition, to have a chance to obtain maximum braking the initial brake application is initiated at 140 knots (landing speed is approximately 215+ knots) and brake pressure relaxed below 40 knots.

3. Criticality of Nosewheel Steering

The nosewheel steering system was recently upgraded to remove catastrophic failure modes. The current system lacks redundancy. The nosewheel steering system offers the only possible means of directional control for the two tire failure case (see item 1 above), allows all available braking capability to be used for stopping rather than for directional control in the presence of crosswinds or for single tire or brake failure.

4. Weather Considerations

Due to the limitations in the landing and deceleration systems and requirement to protect against single credible failures, flight rules and runway rollout margin (runway length remaining after wheel stop) computations have been developed which placard the acceptable wind conditions to values well below those envisioned in original Shuttle design. Conservative application of these placards results in a relatively high percentage of wave offs for landings planned at KSC.

Answer 15: As a minimum, the KSC landing facility continues to be required to support Return-to-Launch-Site aborts and to be available as a weather alternate site for end-of-mission landings. As system improvements/modifications are developed in the brakes, tires, nosewheel steering, and possibly, KSC runway surface, KSC may then return as the primary landing site. The Presidential Commission has recommended that NASA define the conditions under which this can happen.

It should be noted that weather concerns will continue to persist. Exposure of Orbiter tiles to rain damage can present a severe turnaround impact, far more severe than the impact of landing at Edwards Air Force Base in California or Northrup strip in New Mexico. Estimates based upon climatological data and conservative application of flight rule placards suggest that weather wave offs from KSC can be expected from 30 to 40 percent of the time.

Question 16: The tire, brakes, and nosewheel steering systems have been nagging problems for some time. What do you intend to do to ensure that they perform as they should -- what fixes will you incorporate into these systems?

Answer 16: Upgrades to the nosewheel steering systems include elimination of single failure points in control and hydraulic systems. Tire modifications include the addition of tire pressure instrumentation and the possibility of tread redesign pending results of tire testing.

Brake modifications are progressing in two stages. The first reflight will include a new design using thicker stators with current materials and would dissipate at least the same energy as the existing design. A design incorporating new materials (carbon/carbon) will be available in early 1988 which will have an increased energy dissipation capacity. Improvements planned for January, 1987, include stiffer wheel axles and hydraulic system orificing, which should eliminate dynamically induced brake failures; these plus thick stators and brake pressure balancing electronics should increase the energy available for normal and maximum braking stops.

Question 17: According to the Missions Planning and Operations Team, the question of whether a range safety system is appropriate for the Shuttle will be addressed by a joint NASA/DOD review.

What concerns are there about a Shuttle range safety system that would warrant this review?

Answer 17: The current Range Safety System includes explosive elements on the two solid rocket boosters (SRB's) and the external tank. These systems are electrically cross-wired to provide the radio frequency spherical coverage required in this system. As a result of this cross-wiring the range safety commands are not capable of selecting a single system for destruction, i.e., if you destroy the SRB's you also destroy the external tank. The need for destruction of the external tank is generally agreed to be in the timeframe when the vehicle is in the vicinity of the launch pad. If the stack is intact, it may be able to be shown that the act of destroying the SRB's will always destroy the external tank, and analysis may show that if the stack comes apart, the external tank cannot survive. If analysis shows this to be true, the explosive charge on the external tank may not be required.

Removing the system from the external tank has several advantages aside from the obvious cost and weight savings. The fewer explosives you handle in the vehicle preparation activities the safer the operation. Without an external tank system, Range Safety action initiated after SRB separation would not affect the Orbiter or crew and any risk inherent in the external tank system, regardless of how remote, would be eliminated.

The current investigation is in line with the close look currently being given to all other aspects of the Space Shuttle launch process and hardware. The investigation does not represent a concern with the adequacy of the present system, but rather represents a possible improvement which warrants further technical and operational evaluation.

Question 18: The Rogers Commission indicated that if the number of landings at Edwards Air Force Base is increased, NASA may need a second Shuttle carrier aircraft to ferry orbiters back to Kennedy.

What would be the cost of another such carrier and the necessary modifications, how could it be procured, and how long would it take to incorporate the necessary modifications?

Answer 18: The existing Shuttle carrier aircraft is a modified Boeing 747-100. A second Shuttle carrier aircraft would cost approximately 70 to 80 million dollars if a current Boeing 747-200 were purchased and modified. The 747-200 would offer an extended range capability compared to the -100 which is a significant advantage for recovery following a transatlantic landing. Either aircraft would be a used aircraft purchased from military or civilian sources and modified by Boeing. To complete the package, an Orbiter ferry kit and a tail cone would also be required, increasing the total cost to 80 or 90 million dollars. The procurement plus engineering, modification, installation, and testing would require 14 to 18 months.

Launch Abort and Crew Escape

Question 19: The Rogers Commission requested NASA to increase the range of flight conditions under which an emergency landing can be successfully conducted in the event that two or three main engines fail early in ascent.

Generally, what are the limiting factors for abort landings in these conditions, and what are some ways to overcome these limitations?

Answer 19: To do an emergency landing, the Orbiter must have sufficient energy to glide to a designated landing site at the completion of powered flight and must be able to successfully separate from the external tank and fly a return profile which is within the structural design limits of the vehicle. Assuming the current Orbiter hardware remains basically unchanged, this means continuing powered flight at least through SRB separation and shutting down the remaining main engine (if any) such that the Orbiter's range from the runway and residual energy provide for an intact landing.

During ascent the Orbiter flies through a narrow corridor which controls structural stresses and aerodynamic heating within design limits. The process of increasing the range of flight conditions under which the Orbiter can complete an intact emergency landing is one of analyzing this corridor and identifying where within it the Orbiter meets the necessary range and energy requirements. When this is done, engineering analysis must be completed to determine if a profile can be designed to fly the Orbiter successfully to the runway. If analysis and testing indicates the profile is acceptable, the flight software used onboard the Orbiter must then be changed to provide the capability.

The limiting factors then are range from runway, available energy at the end of powered flight, identification of a flight profile which the Orbiter can successfully fly, and the availability of onboard software to fly the profile. These limitations can be addressed through the systematic process addressed above. In fact, the process is already underway with one candidate profile known as Split-S return to launch site already being analyzed. This profile provides for an intact landing for failures of two or three main engines during the first 20-30 seconds of flight.

A related subject is failures where insufficient energy exists either to go back to KSC or to go on to a transatlantic abort site. Contingency abort procedures currently in place result in water ditches. Survivability for these cases is being addressed by the Crew Escape Working Group chartered by the NSTS Program Office.

Shuttle/Centaur

Question 20: When Admiral Truly appeared before this Subcommittee on May 8, he said that NASA was reevaluating the whole Shuttle/Centaur program in light of costs, safety, and flight-worthiness.

What have you learned in the past five weeks?

Answer 20: NASA has completed a reevaluation of the Shuttle/Centaur program and concluded that even following certain modifications identified by on-going reviews, the resultant design would not meet safety criteria being applied to other cargo or elements of the Space Shuttle system. On June 19, 1986, development of the Centaur upper stage for use aboard the Space Shuttle was terminated.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS OF DR. FLETCHER

Recommendation I:

(a) 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. No design options should be prematurely precluded because of schedule, cost, or reliance on existing hardware.

Question 1a: Does NASA favor the total redesign of the solid rocket booster? What are the leading candidates that should be considered? Are the Marshall and Morton Thiokol redesign activities currently under way considering all possible redesign options, including parallel studies of monolithic solid rocket boosters?

(b) How long does it take to develop, test and qualify a new solid rocket booster or a redesigned solid rocket booster? What does it cost?

(c) Is there any truth to the rumor that Morton Thiokol already has a redesign candidate for the solid rocket boosters? Does this option incorporate a capture joint? Does it still have O-rings?

Answer 1a: The SRM failure on STS 51-L was isolated to the SRM field joint and seal design. A comparable design was used on the SRM case to nozzle joint and seal. However, the secondary seal in that joint was insensitive to joint rotation and therefore more resistant to failure. Design actions are underway to correct joint and seal designs for both of these joints. In addition, a detailed assessment of the entire SRM design has been performed and design actions are being taken to enhance the reliability of the SRM. Specifically, the number of potential leak paths is being reduced in the igniter and the margins of safety are being improved in the nozzle. These improvements are being defined by independent NASA and Morton Thiokol teams to produce a reliable SRM design utilizing the facilities and major tooling capability already in place at MTI. Both design teams are charged with the responsibility for evaluating alternate designs to ensure adequate program margin. All of this activity is being reviewed with the National Research Council Overview Committee. A separate SRM design study will be initiated involving all solid rocket motor manufacturers to evaluate other design solutions. These studies will not be limited to the current concepts and will include evaluation of monolithic SRM's.

Answer 1b: Based on historical experience on development of large solid rocket motors (SRM) we would estimate a minimum of 4 years required to design, develop, and qualify a new Shuttle SRM. The current Shuttle SRM required approximately 6 years from initiation of the contract to completion of qualification. This time could be reduced some on the basis of the experience gained during Shuttle SRM development program if you were developing an SRB with identical performance. Using the Shuttle SRM development cost as a basis for projecting the cost of developing a new Shuttle SRM,

the estimated cost would be $500 to $600 million real year dollars. This estimate simply takes the Shuttle SRM cost and escalates that cost to the time frame for development of a new Shuttle SRM. The minimum 4 years estimated development and qualification for a new Shuttle SRM is exclusive of procurement time to competitively select a supplier. This would add 12 to 15 months to the overall schedule. A redesign of the booster including qualification testing should be accomplished in less than two years. The cost to qualify a redesigned booster is included in the FY 1986 supplemental already approved by Congress.

Answer 1c: It is true that Morton Thiokol and NASA have redesign candidates. The redesign candidates address all potential or contributory failure causes identified in the 51-L investigation. There are two leading concepts for the metal case field joint part of the redesign and both of these concepts include capture features and O-rings.

Question 2: The Commission recommends static firings of the final flight configuration. Does a suitable test facility exist for vertical tests of this nature? How many tests should be conducted to verify the redesigned joint and under what conditions? What are your best estimates of the cost of (a) refurbishing a suitable test facility and (b) of each vertical test?

Answer 2a & b: There are no existing facilities capable of testing the Shuttle SRM vertically (nozzle up or nozzle down). The verification plan being implemented includes tests on subscale fixtures, full segments, and flight configuration solid rocket motors. The subscale tests will be conducted on fixtures less than 2 ft. in diameter simulating field joints primarily to evaluate sealing performance using various seal types and materials under wide temperatures and dimensional extremes. Other subscale tests will be conducted on small motors hot fired to evaluate seals, insulation, thermal behavior, etc., with varying tolerances. Full size joints will be tested to evaluate and develop joint environmental protection (temperature and rain) designs and to verify computer models of joint dynamic behavior. Three to five full size segments will be assembled vertically into two shortened motors containing inert propellant. Small igniters will be installed in these shortened motors and fired to produce near identical pressure profiles as experienced during actual SRM ignition. These shortened vertical motor tests will be used to evaluate the joint movement under dynamic conditions and the pressuring hot gas dynamic effect on the insulation gap and joint sealing capability. Appropriate full size segments will be assembled into a structural test article that will be subjected to flight loading conditions. Finally, four full scale motor static hot firings are planned to be tested either horizontally or vertically. All these tests are to be conducted over the SRM range of environmental conditions. This testing will be coupled with detailed extensive analysis to verify the joint design.

Cost estimates are being developed at this time. Very preliminary rough order magnitude (ROM) estimates indicate a totally new nozzle down vertical test facility would cost between $50 and $60 million, a refurbished nozzle down test facility would cost between $40 and $50 million, and a refurbished nozzle up test facility would cost

between $20 and $30 million.

Test cost could vary significantly based on test site location. The only basis available at this time for estimating cost per test is horizontal testing at Morton Thiokol which cost approximately $15 million per test. This includes the test motor cost, test crew cost, instrumentation cost and engineering support cost.

Question 3: Under the original research, design and development activities for the solid rocket boosters, what factors caused the abridged test program? Why hadn't Morton Thiokol conducted tests that conformed with the temperature requirements of the Launch Commit Criteria?

Answer 3: Verification of the SRM to the natural and induced environmental requirements was planned early in the program to be conducted by analysis and test. Morton Thiokol eventually certified the joint for induced temperature through analysis only. In retrospect the resulting certification was inadequate. Additionally, when questioned by the NASA Data and Design Analysis Task Force during the investigation of the accident, Morton Thiokol stated that they had misinterpreted the vertical flight environmental requirement for a storage requirement.

The requirements for matched performance between the two SRM's were a major concern during the development phase. These requirements were more stringent than previous SRM programs to ensure vehicle control and maximum performance. As a consequence, the full scale motor test program was oriented toward testing at ambient temperatures to minimize ballistic performance variables. The concern for ballistic performance verification coupled with the inadequate plan for analytical environmental verification, resulted in insufficient verification of the thermal effects.

(b) 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.

Question 1: Does NASA interpret this recommendation to infer that the NRC will participate in the formulation of the redesign candidates? Has Dr. Stever already initiated NRC activities? Who will be members of the NRC group? Who makes the final SRB fix decision? What will be the critical factors -- cost, safety, reliability, availability?

Answer 1: The NRC Panel of experts will participate in the formulation of the redesign candidates to the extent that they will conduct technical evaluation of key steps in the redesign process. The Panel will review and comment on the technical adequacy of scheduled NASA reviews of the redesign and provide written and oral reports to the NASA Administrator.

The NRC has formed a Panel with Dr. Stever as Chairman. (An NRC news release listing the Panel members is attached). The first meeting of the Panel was held on June 19 and 20 at the National Academy of Sciences. NASA and Morton Thiokol personnel provided

orientation briefings to the Panel at that time.

The final SRB fix decision will be made by the NASA Administrator following formal reviews through the NASA configuration change process and reviews by a NASA/industry design overview team and the NRC Panel. The critical factors in the SRB fix decision will be safety and reliability.

Question 2: What impact does the ongoing NASA Criticality 1 Review have on these activities and the possible candidates?

Answer 2: The new design will be assessed as part of the overall criticality 1 review process. When the design is defined, a Failure Mode and Effects Analysis (FMEA) will be conducted on this design and any criticality 1 and 1R components will be evaluated to ensure adequacy for flight safety.

Question 3: Should alternatives such as monolithic solid rocket boosters be candidates?

Answer 3: The SRM design team has not restricted itself to any particular design options. If a "seal system" configuration provides the safety requirements and complies with the criteria established by the Presidential Commission, this type of configuration would be advantageous to the program since a monolithic design presents other problems such as reusability, transportation, re-verification, etc. However, a monolithic design has not been deleted as a design option.

Question 4: Doesn't a comprehensive reassessment of solid rocket motor designs and the development, testing and requalification of the ultimate selection infer an extended down time for the Shuttle?

Answer 4: The primary factor in the selection of a redesigned SRM seal is safety. In the event the final design necessitates an extended down time, the flight program will be delayed until a safe seal design is verified.

Recommendation II:

(a) Shuttle Management: The shuttle program structure should be reviewed... A redefinition of the Program Manager's responsibility is essential.

Question 1: Does the current management review being conducted by Sam Phillips meet the full scope of this recommendation? How does Captain Crippen's review of space shuttle management interface with Gen. Phillips? Should an outside organization such as the National Academy of Public Administration's or some other group's support be enlisted in conducting this management study?

* Answer 1: General Sam Phillips has been charged by Dr. James Fletcher to review the overall NASA management structure. Captain Crippen's effort is a subset which will specifically address the Commission recommendations by reviewing Space Shuttle management. The results of the Crippen study will be reviewed with General Phillips. This study will also be reviewed by an outside

organization.

Question 2: How will NASA be able to attract and maintain top level management personnel in light of the current hiring freeze and the restrictive revolving door policy?

* Answer 2: NASA has continued to develop outstanding young men and women who are ready and willing to move upward in the ranks of management. Also, in this time of need, many excellent people outside of NASA have volunteered their services to put the program back on track.

(b) Astronauts in Management: NASA should encourage the transition of qualified astronauts into agency management positions.

Question 1: At what level and in what positions would former astronauts enhance the appreciation of operations and flight safety?

* Answer 1: The backgrounds and experience levels of the individuals in the astronaut office are widely varied. Depending on the individual involved, they can serve in any management position for which they are qualified.

Question 2: Does NASA offer enough benefits and challenges to retain top rated NASA astronauts?

* Answer 2: The Crippen study will address the incentives for retaining astronauts in management. Many individuals in this group, as well as the rest of the NASA family, are rewarded by the knowledge they are participating in a challenging endeavor that is important.

(c) Safety Shuttle Panel: NASA should establish an STS Safety Advisory Panel.

Question 1: How would this Panel interact with the Commission's proposed creation of an Office of Safety, Reliability and Quality Control within NASA?

* Answer 1: The STS Safety Advisory Panel would be a separate entity from the SR&QA office. Its function would deal with issues that involve flight safety as opposed to safety in general. The intent is to have this panel work closely with the SR&QA office as well as the operations and engineering organizations of NASA.

Question 2: Is quality control a function of an organizational chart, or is it the result of a line item emphasis?

* Answer 2: Quality is obtained by emphasis on its importance to all individuals involved with a product and an organization with adequate checks to ensure the integrity of the product.

Question 3: How will NASA be able to attract qualified technicians and engineers to safety/quality control-related issues when in the past it was a dead end career slot?

* Answer 3: In responding to the Commission's recommendation

regarding an SR&QA office as well as a safety panel, the agency has planned a renewed emphasis on this vital function. The outcome will be a natural career progression plan for this field.

Question 4: Would the Shuttle Safety Panel have the authority to terminate or delay a launch?

* Answer 4: The exact role of the Shuttle Safety Panel in the launch decision process is under study.

Recommendation III:

Criticality Review and Hazard Analysis: NASA and the primary shuttle contractors should review all Criticality 1, 1R, 2 and 2R items and hazard analysis. An Audit Panel, appointed by the National Research Council, should verify the adequacy of the effort and report directly to the Administrator of NASA.

Question 1: Does this effort infer only a review of current Criticality Items Review methodology? Or does it mean an independent outside group will reassess all criticality items?

Answer 1: The failure modes and effects analysis (FMEA), critical items list (CIL), and hazard analysis (HA) re-evaluation effort entails complete reviews of design and existing FMEA's, CIL's, and HA's to ensure completeness, and/or the need for additions or deletions. The re-evaluations are being conducted by each NASA project element and element contractor and by independent contractors (FMEA's and CIL's only). The independent contractors assigned to do the FMEA and CIL re-evaluations are as follows:

a. Orbiter and Government-furnished equipment (GFE), McDonnell Douglas Astronautics Company

b. Space shuttle main engine (SSME), Martin Marietta Aerospace

c. External tank (ET), Rocketdyne

d. Solid rocket booster (SRB), Martin Marietta Aerospace

The data derived from these reviews will be integrated and reviewed by the projects in a series of internal reviews. The data will then be submitted to a series of official NASA project, program, and Headquarters boards for review. In conjunction with this review effort, the instructions for preparing FMEA's and CIL's and for performing the analyses are also being re-evaluated to assure that groundrules and assumptions used in performing the analyses are valid and will yield accurate and consistent results. In an effort to assure that the methodology is consistent across all elements, Level II is preparing documentation requirements which would formalize the methodology for FMEA's and CIL's.

In addition, Presidential Commission Recommendation III requests that an audit panel be appointed by the National Research Council to verify the adequacy of the re-evaluation effort and to report directly to the Administrator of NASA.

Question 2a: Doesn't the current NASA review of the Critical Items list already include an independent review by outside contractors?

(b) When will NASA complete its Critical Items list review?

Answer 2a: As part of the FMEA and CIL re-evaluation process, each project element is using the services of an independent contractor along with those of an element prime contractor. Prior to STS 51-L, however, there was no independent contractor duplicating the effort of the element prime contractor. After being reviewed by each NASA project element. The project element reviews included assessments by the responsible design organization and the JSC Reliability Division. The CIL was then submitted to the Levels II and I boards as required. Information copies of the CIL were also submitted to other organizations, including the JSC Mission Operations Directorate, JSC Safety Division, and the JSC Quality Assurance Division.

MSFC management is overviewing the FMEA and CIL re-evaluation tasks being performed by the MSFC engineers, the prime contractors, and an independent contractor for the SSME, ET, SRB, and Spacelab projects. JSC management is performing the same overview for the Orbiter and GFE. In addition, JSC and MSFC managements and a JSC Level II team (comprised of Reliability Division, Astronaut Office, and Flight Crew Operations Directorate personnel) are surveying each of the element contractors to assure their methodology is correct.

During the period when the FMEA's and CIL's are being re-evaluated, Level II SR&QA personnel will be resident at the NASA project element and element contractor facilities.

As the FMEA and CIL re-evaluations are completed, the results will be submitted for review to a series of official boards at each of the project facilities, then the Level II (program office) board, and finally to the Level I (Headquarters) board.

At the completion of this process, the Office of the Administrator will initiate action to have an audit panel appointed by the National Research Council to provide an end audit of this activity.

Answer 2b: Although completion of the Level I critical items list review has not been scheduled, it is anticipated that the Level I review will be completed by the end of June 1987 and that the Level II review will be completed in May 1987. This timetable, however, does not necessarily provide for identifying any new critical items which may become a part of present or future new designs.

Question 3: NASA recently released a list of 44 Criticality I items that would require changes before the shuttle flew again. This was part of the System Design Review.

(a) Does this mean these items presented unnecessary risks? Why hadn't they been reworked before the accident? And to "require changes" does this infer analytical work or redesign/engineering work?

(b) Are there any other Criticality I items, besides the O-rings, that required a launch constraint waiver on Flight 51-L or any other flight? What are they?

Answer 3a: The 44 Criticality Items list referred to includes the elimination of SRB nozzle erosion. This problem occurred on STS-8 and subsequent to this flight the material which was subjected to erosion was replaced on all subsequent flights. A redesign will be evaluated utilizing the planned static test firings.

Answer 3b: There were 4 Criticality I Items besides the O-rings that the Shuttle Projects Office identified as a launch constraint in the MSFC Problem Assessment System (PAS) on flight STS 51-L. They are as follows:

1. APU problem which caused an abort prior to liftoff on flight 61-C. The problem was found to be comparitors in the APU speed controller that caused an SRB right tilt APU overspeed. This was a new comparitor obtained from a different vendor and used for the first time on flight 61-C. These comparitors were removed from the system for all subsequent flights. This problem was still open pending resolution of eliminating two unused terminals.

2. Improper torque on an SRM Transducer Bolt Assembly. This problem was found during post flight inspection. The cause was found to be torquing interference using the torquing tool. The bolts have been retorqued and leak checked on all subsequent flights. Revised torquing requirements have been implemented and a new torquing tool developed to eliminate this problem.

3. Missing section of SRM outer boat ring. Missing material from the outer boat ring occurred on DM-4, 51B, 41G, 41C, 41A, STS-3. Analyses of the structure indicates the failure occurs at 85 seconds in the burn. The worse case analyses indicates that separation could not occur prior to 85 seconds after ignition, and thermal analysis indicates a failure would not occur for this worse case condition. Corrective actions are in process.

4. SRM igniter gasket erosion damage. Erosion damage of the primary seal of the inner gasket and hot gas flow between the primary and secondary seals was found during post test inspection of the DM-6 static firing. Investigation revealed the anomaly could be caused by either an overfill of the rubber seal, torque relaxation of the bolts, tolerance stacking between mating parts and deformation of the cover during ignition. Corrective actions are underway.

Recommendation IV:

Safety Organization: See Recommendation II(c).

Question 1: Does this recommendation indicate that NASA had downgraded its safety, reliability, and quality assurance activities despite their prior arguments to the contrary?

Answer 1: We believe that this recommendation reflects Commission conclusions that (1) there should be an Office of Safety, Reliability and Quality Assurance headed by an Associate

Administrator, (2) this office should have direct authority for safety, reliability and quality assurance, (3) this office should have a work force sufficient to insure that its functions are adequately performed, and (4) this office should be independent of other NASA functional and program responsibilities.

Question 2: Wouldn't the consolidation of safety/reliability/quality assurance activities at the Associate Administrator level further reduce its priority at the program and project level -- create a situation where safety/reliability/quality assurance would be seen as the other guy's problem?

Answer 2: The establishment of an Office of Safety, Reliability and Quality Assurance at the Associate Administrator level does not in any way relieve the program Associate Administrators of the responsibility for safety, reliability and quality assurance in the execution of their programs.

Recommendation V:

Improved Communication: 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.

Question 1: In light of this finding, what confidence should this Committee have in other programs and projects managed by the Marshall Space Flight Center including the external tank and the space shuttle main engine?

Answer 1: The management structure for the external tank program is essentially the same as that for the solid rocket booster program. Both are production programs and basic development is considered complete. The external tank program has an excellent history of problem reporting to all levels of NASA management.

The SSME is an on-going large flight and development program with known problems that are being worked on. The solid rocket booster program was not structured for continued development. Following the development phase, it was considered essentially a production program. The SSME can limit the life of a component if a problem comes up. This has been done on the turbine blades, etc. The solid rocket motor had to be designed/developed differently because its failure modes were not a function of lifetime.

Question 2: How many Criticality 1 launch constraints were waived each flight for the SRBs? ET? SSMEs? and Orbiters?

Answer 2: No answer yet.

Question 3: Despite the fact Morton Thiokol's and Rockwell's concerns were not addressed to the Mission Director for 51-L, shouldn't upper level management be aware of the "critical" Criticality I items that most threaten the success of the mission? Wouldn't a waived launch constraint constitute such an item? Aren't waived launch constraints addressed as part of the Flight Readiness

Review (FRR) process?

* Answer 3: Upper level management should be and is aware of the numerous critical items associated with the vehicle. They certainly should be aware of any imposition and removal of constraints associated with these items. The waiver of any such constraint should also be addressed at the FRR. This was not the case for the SRM seals. A mandate of the Crippen study is a policy that will ensure this information flow in the future.

Recommendation VI:

Landing Safety: NASA must take actions to improve landing safety.

Question 1: Does the Commission have any particular recommendations concerning improvements in the tire, brake and nose wheel steering systems on the shuttle?

Answer 1: The Commission recommends that the safety margin, particularly at abort sites, be improved on the tire, brake and nosewheel steering systems. They also recommend that specific criteria be established for these systems and that the systems be required to meet these criteria in high fidelity testing that is verified at Edwards prior to landing at KSC.

NASA is taking action to improve the safety margin as recommended by the Commission. The abort site capability of the brakes will be increased approximately 50 percent through the use of structural carbon brakes in lieu of the baseline beryllium brakes. Design studies are being conducted on a fail operational/fail safe nosewheel steering system in lieu of the present fail safe system and on methods to reduce tire wear and the chance of a tire blowout. As potential backups in case of a blown tire, studies are being conducted on landing gear emergency skids and a roll-on-wheel rim capability. Based on the results of the studies, additional improvements will be made as required to insure landing safety. The improvements will be certified to specific criteria through high fidelity ground and flight testing.

Question 2: Despite significant efforts to improve these systems, they still do not have sufficient safety margins. Why? Are inadequate resources being devoted to these activities?

Answer 2: It is not felt that inadequate resources have been devoted to improving the landing systems. The original approach to solving the brake damage problem was to fix the baseline beryllium brakes. Considerable effort was expended in this direction, however, ground and flight test results have demonstrated that the baseline brakes do not have sufficient capability to provide for landing under all conditions. It is now planned to develop a new set of brakes (structural carbon) with sufficient capability to provide for safe landings under both normal and extreme abort conditions.

The nosewheel steering system was originally designed to be used for contingency purposes and not as a primary steering system. The brakes were utilized as a primary steering system through differential braking. To offload the brakes, the nosewheel steering

system has been upgraded to a fail safe primary steering system.

Consideration is being given to further upgrading the nosewheel steering system to a fail operational/fail safe system to insure its availability for primary steering.

Question 3: Do landings at the Kennedy Space Center represent an excessive safety risk?

Answer 3: Shuttle landings can be made at the Kennedy Space Center without excessive risk when "good weather" conditions exist. However, weather prediction can be a problem when the weather conditions are marginal. Improvements in weather prediction capability, as well as improvements to the orbiter brakes, tires, and nose wheel steering, would reduce that risk even further. Therefore, NASA plans to resume Shuttle flights with landings at Edwards Air Force Base and incorporate these improvements before resuming landings at KSC. The brake improvements and additional equipment for more accurate weather forecasting are in process and scheduled for implementation with demonstration tests during the first year after resuming flying. Nose wheel steering with fail--safe features is available for the next flight and decisions on whether to incorporate fail-operational features are scheduled for December 1986. After these modifications and with conservative margins in weather forecasting, there will be even less risk in landing at KSC.

Question 4: Besides improving landing weather forecasts, do launch weather forecasts also require substantial enhancements and improvements? Does the existing forecasting system provide adequate wind shear forecasting capabilities? If so, why was Mission 51-L exposed to hurricane-level gusts?

Answer 4: The Office of Space Flight has been reviewing the Shuttle weather forecasting capabilities since the formation of the Space Shuttle Weather Advisory Panel in the fall of 1985. The panel consists of distinguished scientists and managers on atmospheric operations and research. They have made a complete review of NASA's current operational weather forecasting system and will provide recommendations to OSF for system improvements in their final report expected this month.

A NASA team will review and formulate a system-wide Space Shuttle Weather Improvements Plan upon review of this report. This team will be responsible for assessing both the short and long term research/forecast weather improvement requirements for the Space Shuttle.

Wind shear detection is not a separate characteristic affecting launch policy, since some level of wind shear typically exists. This phenomena is not specifically addressed as a separate element impacting launch decisions. However, it is included as part of the wind profile and integrated to determine whether the overall wind profile/initialization load is within acceptable limits for launch.

There were indeed strong wind shears aloft over KSC when Challenger was launched; however, these shears did not appear to exceed its operational design limits. Wind shear detection will be included in

the issues reviewed by the NASA Weather Improvement Team.

Recommendation VII:

Launch abort and crew escape:

Question 1: Would you please inform the Committee as to the various launch abort and crew escape systems that exist during the various stages of a launch? Are any launch abort or crew escape systems feasible during the two minutes ignition period of solid rocket boosters?

Answer 1: The early part of the ascent phase in which the main engines and SRB's provide the thrust is known as "first stage". "Second stage" begins after SRB separation and continues until main engine cutoff (MECO). Any system failure during the "first stage" will result in an abort situation being declared. The current design of the Space Shuttle requires a delay in execution of the abort sequence until after SRB separation.

There are two basic types of ascent abort modes for the Space Shuttle missions: intact aborts and contingency aborts. Intact aborts are designed to provide a safe return of the Orbiter to a planned landing site. Contingency aborts are designed to enhance crew survival following a failure when an intact abort is not possible.

The type of failure and time of the failure determine which type of abort is selected. There are four types of intact abort modes: ATO, AOA, TAL, and RTLS. The abort-to-orbit (ATO) mode is designed to allow the vehicle to achieve a temporary orbit that is lower than the nominal orbit. The abort-once-around (AOA) mode is designed to allow the Orbiter to fly once around the Earth and make a safe entry and landing. The transatlantic-abort-landing (TAL) mode is designed to permit an intact landing on the other side of the Atlantic Ocean. The return-to-launch-site (RTLS) mode involves flying downrange to dissipate propellant and then turning around to return to a landing near the launch site. The Contingency abort mode requires a relatively intact landing on a prepared runway or a successful water ditching if a runway cannot be reached. The chances of a successful ditching are low. The crew will probably not survive due to structural failure at water impact. For all abort modes, the crew escape procedures require the crew to stay inside the crew compartment until the Orbiter lands or ditches. At that time the crew egresses from the Orbiter.

Two concepts may provide some remote possibility of launch abort during first stage flight. The first concept involves the removal of the crew from the Orbiter. Possible escape systems to safely remove the crew from the Orbiter include ejection seats, encapsulated seats, or a specially designed crew compartment that would separate from the Orbiter. The other first stage abort concept involves the separation of the Orbiter from the SRB and ET stack. Possible escape systems that could enhance separation of the Orbiter include SRB thrust termination and a fast separation capability. However, complex systems such as these have their own inherent risks and penalties (such as cost, weight, and unintended actuation or hardware failure). If major changes such as these do

not significantly reduce overall risk to the crew and end up cutting the Shuttle's payload capacity significantly, that would not be the prudent thing to do. Feasibility, then, must be put in its proper perspective by weighing it against the overall impact of making the changes.

Question 2: Prior to 51-L, had NASA discussed the feasibility of incorporating enhanced launch abort or crew escape systems into the orbiter?

Answer 2: Yes. The feasibility of enhanced launch abort or crew escape systems was studied in detail. Criteria for selecting a system for enhancing crew survivability included technical complexity; limited utility of the system due to lack of crew reaction time; cost, schedule, performance and mission objective impacts; and probability of need based upon predicted system reliability.

Appendix C of the Data and Design Analysis Mission Planning and Operations Team Report includes a summary of that history up until the STS 51-L accident. A more current review (the Louviere Report) of the entire subject is in progress and should be completed by October 1, 1986.

Question 3: Allen Louviere's report on Crew Escape Provisions is due for completion on June 15th.

(a) When will the Subcommittee receive a copy of this report, and are you familiar with its findings and recommendations?

(b) Will shuttle crew size be reduced when the shuttle resumes flights?

(c) Is NASA reassessing the Space Flight Participant program and certain categories of the Payload Specialist Program? Shouldn't space flight be left to the professionals for the near term?

Answer 3a: The National Space Transportation System (NSTS) Program Manager received an interim oral presentation on Crew Escape Provisions on 30 June 1986. The study is continuing and should be completed by October 1, 1986. Copies will be provided to the Subcommittee as soon as the written report is available.

* Answer 3b: The Louviere study, which is due for completion on October 1, 1986, will address crew size in its proposals, but its objective is a design that will not limit crew size. Crew size will certainly be addressed as a major concern prior to the next flight.

* Answer 3c: NASA will address the Space Flight Participant program for future operations to ensure a coherent policy for this program. While such participants will not be a part of the initial flights, it is anticipated that NASA will continue to support this program in the future.

Recommendation VIII:

Flight Rate: NASA must establish a flight rate that is consistent with its resources. Reliance upon a single launch

capability should be avoided in the future.

Question 1: Does the Commission's recommendation indicate that NASA should have both an ELV and a shuttle capability?

Answer 1: NASA supports the mixed fleet concept. The DOD has been authorized to proceed with the procurement of ELV's for national security purposes. Any NASA requirements for ELV's will be met by procurement through DOD or the private sector.

Question 2: Does NASA feel the use of manned launch vehicles should be reserved for select missions that utilize the shuttle's unique capabilities?

Answer 2: There are many missions that can be accomplished only with a manned launch vehicle, but the Shuttle's capability allows its use for almost any type of payload. The Shuttle's capacity will be utilized for mixed cargo flights according to pending policy decisions.

Question 3: Does NASA intend to restrict foreign and commercial launches on the shuttle? What were the feelings of the Commissioners on this issue?

Along a similar line, what were the feelings of the Commissioners toward the launch of citizens in space?

Answer 3: NASA intends to meet its commitments to our foreign and commercial customers. However, NASA will not compete with private ELV entrepreneurs for new customers. The report of the Commissioners did not express any feelings on these two subjects. The policy on the launch of foreign and commercial satellites is currently under interagency review and a policy is expected shortly.

Recommendation IX:

Maintenance Standards: Installation, test and maintenance procedures must be especially rigorous for space shuttle items designated Criticality I.

Question 1: Can a vigorous maintenance program be maintained in conjunction with an ambitious launch schedule?

Answer 1: A vigorous maintenance program will be maintained at whatever level is required to ensure safe operations and flight. The launch schedule will reflect whatever that maintenance program requires in terms of time and effort.

Question 2: Is there a fear that an overemphasis on Criticality 1 and 1R items could result in an associated decline in concern and awareness of Criticality 2 and 2R items?

Answer 2: No, but there is an awareness that the entire reliability and quality assurance program must be balanced. The criticality of all STS components is currently being reviewed and appropriate guidelines are being established for dealing with each level of criticality.

Question 3: Has NASA's emphasis on structural spares and new orbiters come at the expense of the spares program? What activities are under way within NASA to put the spares program on a stable footing?

Answer 3: We do not believe NASA has emphasized structural spares and new Orbiters at the expense of the spares program. The structural spares are a separate budget line item as required by Congress and the initial funding for a replacement orbiter is proposed in a budget amendment.

As Program Manager, Arnold Aldrich reported to the Commission:

> "There had been fund contentions in the program for a number of years, at least starting in the mid-seventies and running through into the early to mid-eighties...intentional decisions were made to defer the heavy build-up of spare parts procurement in the program so that the funds could be devoted to other more pressing activities"

One major step being taken to put the spares program on an operational basis is the assumption of Logistics Management by the user organization, KSC. Locating this responsibility at the launch center will provide greater visibility and emphasis to this area. During the current internal budget cycle, special emphasis is being placed on the Logistics program. KSC as the responsible center has performed an in-depth requirements review and have presented their findings and recommendations to Headquarters. These findings and recommendations are being incorporated into the agency's planning and budget process.

U.S. SENATE,
COMMITTEE ON ARMED SERVICES,
Washington, DC, February 19, 1986.

Hon. SLADE GORTON,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, Washington, DC.

DEAR MR. CHAIRMAN: Enclosed is a letter and material[1] provided me by a constituent regarding the malfunction of the space shuttle Challenger which resulted in its explosion on January 28. I would appreciate your including it in the record of the oversight hearing held on the explosion of the space shuttle.

I certainly appreciate your cooperation in this matter.

Sincerely,

SAM NUNN.
U.S. Senator.

Enclosures.

MARIETTA, GA, *January 31, 1986.*

Senator JAKE GARN,
Senator SAM NUNN,
Senator MACK MATTINGLY,
U.S. Senate Building,
Washington, DC.

GENTLEMEN: May I pass onto you three gentlemen several ideas which I believe you might entertain in your deliberations?

First, may I tell Senator Garn my admiration in the way he conducted and so feelingly expressed himself in regard to the Challenger tragedy on the McNeil-Lehrer TV Newshours this sad week in our Nation's history. Likewise, to Senator John Glenn.

It is in regard to the above catastrophe that this letter is expressed.

While Director of the Engineering Sciences Division of the U.S. Army Research Office at Duke University during the 1960s and 1970s, I carried out both a theoretical and experimental research program. This work was done in collaboration with two outstanding engineering scientists, namely Dr. Sudhir Kumar, the Associate Director of the Division and Dr. Charles M. Harman, Professor of Mechanical Engineering at Duke.

The subject of our research, named Project Mountainwell which the Army sponsored in both our spare time and funds along with the Duke University facilities, was missile propulsion using atmospheric thrust through a sealed air-evacuated tube. This work was active from 1961 through 1975 and resulted in over a dozen technical (reviewed) journal papers, six Ph.ds and numerous M.Ss. in engineering. Since the research was in the field of rocket propulsion, we informed the NASA group in Houston of our findings. In fact, it was favorably referred to by a paper that was issued by the NASA Lewis Laboratories.

This scheme enabled a missile, such as the Apollo series, to dispense with or reduce its first propulsion stage in that the atmospheric thrust supplied the initial thrust. This thrust phase would be available using a two thousand foot long, twenty foot wide vertical, air-evacuated tube. The tube would be structurally mounted alongside, or within, a vertically sheer precipice such as are plentifully available in the Glenwood Springs area of Colorado. A plastic, convex, muzzle air seal (at the exiting top of the tube) would be explosively timed to disintegrate as the missile entered the exit position. Not only is a considerable portion of the fuel supply reduced to attain an upward velocity of 900+ fps at exit, but the missile overall volume and carried throw-off weight can be much reduced. Greater exiting velocities are attainable, should the atmospheric thrust within the tube be implemented with a solid state reduced propulsion first stage.

The choice of an enclosed first stage operation in a protected tube presents several advantages, namely: the vehicle or missile exits into the lower atmosphere in an aerodynamically stable configuration, the possible atmospheric turbulence or weather does not interfere with a chosen time for launch of a mission, and there is considerable savings and enhanced safety in reducing the need to carry other than solid propellants for the initial phase of early flight. The aspect of precise scheduling, independent of weather, lends dependability for construction of a orbitalling space

[1] The material was not reproducible.

launch platform. Furthermore, the Glenwood Springs altitude above sea level grants a definite advantage in fuel expenditure.

The experimental work was carried out at Duke University, initially using one inch short tubes and finally after several years, a one foot diameter steel pipe that was 1870 feet long. Speeds of over 500 fps were attained at midpoint inside of the later tube for vehicles weighing more than 80 lbs. I believe that the Duke one foot facility, although needing some policing in the forest location, could be revived for tests.

Both Dr. Kumar, now Prof. of Ae/ME at the Illinois Institute of Technology, Chicago; and Dr. Harman of Duke, are actively continuing research and fully familiar with this now inactive project. I know that they would both be most interested in relating to you their participation in that project and any aspect that you would question. I called both last Tuesday evening after seeing the Newshour mentioned above. Incidentally, Dr. Kumar and I were awarded one of the Army 1966 R&D Awards for our earlier work on this study.

I will be pleased to address this subject further, should you request.

Sincerely yours,

JAMES J. MURRAY.

Encl.: Project Mountainwell early site photo. Copy of first Mountainwell paper, ARS Jounral, Oct. 1961.