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REPORT OF THE NATIONAL COMMISSION ON SPACE

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

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SECOND SESSION

ON

Report of the National Commission on Space

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Dr. PAINE. Yes, we are going to have to go and present our report now to the head of NASA, in the ultimate sense, that is, the President.

I must say in response, Mr. Chairman, that I think all of us on the Commission, both the Commissioners and the staff, are enormously grateful to you for having given us this question and then the resources to spend a year looking at it.

I might say, because Senator Rockefeller has emphasized the financial bind, that we are very proud of the fact that we brought it in not only on time but below the budget that was allocated.

Senator GORTON. We are very pleased with that, too.

Senator ROCKEFELLER. And in color, too.

Senator GORTON. Yes. We are in your debt.

Thank you very much.

Dr. PAINE. Thank you, Mr. Chairman.

Senator GORTON. Our next witnesses will be Dr. Van Allen and Dr. Donahue.

[Pause]

Senator GORTON. The meeting will come back to order.

Dr. Van Allen, we are delighted to welcome you here and to hear from you.

STATEMENTS OF DR. JAMES A. VAN ALLEN, DEPARTMENT OF PHYSICS AND ASTRONOMY, UNIVERSITY OF IOWA, AND DR. THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES

Dr. VAN ALLEN. Thank you very much, Mr. Chairman.

I am very grateful for this opportunity to participate in your hearings today.

I have a short written statement which I should like to read. In addition to that, I have two other documents which I have deposited with the staff.

Senator GORTON. Fine. They will be included in the record by reference.

Dr. VAN ALLEN. Thank you very much.

Let me say that this would be a very dull afternoon if we were all to agree. So I already promise that that will not be the case.

It is courageous, perhaps even foolhardy, to go on the public record with an agenda for the next 50 years, especially in a highly technical field. For example, I have not found any anticipation of the invention of the transistor in forecasts of 50 years ago. Yet today the transistor and associated electronic techniques have revolutionized communications and computing, and have made possible numerous devices in daily use by the general public. And they are of crucial importance to sophisticated space equipment.

It is very easy to visualize ambitious projects in space. Such projects have been the stock in trade of science fiction writers for many centuries. With no difficulty whatever, I can think of a billion dollar space

project before breakfast, any day of the week, or a multibillion dollar project before breakfast on Sunday.

I might comment that my favorite project for this week is to land the first human crew on the planet Pluto and return it safely to Earth. That is somewhat beyond the scope of the commission's report.

The "Report of the National Commission on Space" contains no essentially new concepts or new material. It is, however, an excellent digest of concepts and aspirations that have been a part of our culture for many, many years.

A few examples of its worthy antecedents are: Willy Ley and Chesley Bonestell's 1951 book, "The Conquest of Space;" Wernher von Braun's 1952 book, "Das Marsprojekt;" and a series of articles by von Braun, Fred L. Whipple, and other authors in "Collier's Magazine" during 1952 to 1954.

Coming more precisely to the issue at hand today, I wish to refer to a famous Federal document entitled "The Post-Apollo Space Program: Directions for the Future—Space Task Group Report to the President," dated September, 1969.

This report was prepared in response to a directive issued by President Nixon soon after his inauguration in early 1969.

I was a member of his pre-inaugural committee on space and have a clear recollection of his reaction to our advice and of the basis for his directive.

The Space Task Group consisted of Vice President Spiro T. Agnew, as Chairman; Robert C. Seamans, Secretary of the Air Force; Thomas O. Paine, Administrator of the National Aeronautics and Space Administration; and Lee A. Dubridge, Science Advisor to the President.

I have re-read this 17 year old report recently—in fact, I have a copy with me today—and find that its substance, including budgetary projections for various options, is virtually identical to that of the 1986 report of the National Commission on Space.

The Agnew Report was delivered to the President only a few months after the first Apollo landing on the Moon in July, 1969.

Despite NASA's well-earned acclaim for this achievement, the budget of the agency was already declining rapidly at that time. The Task Force's recommendations did not reverse this trend. In fact, manned exploration of the Moon was discontinued abruptly in 1972, and the annual budget of NASA finally levelled off at about one-third of its 1964 peak, measured in normalized dollars.

This level of effort has remained essentially the same at a frozen level for the past 12 years, representing, I think, a kind of political/sociological equilibrium between advocates and skeptics of civil space activity.

In partial response to the Agnew Report, NASA proposed to develop a reusable space shuttle in order to make a drastic reduction in launching costs.

On several occasions in 1971 and 1972, I sat at this witness table in hearings of your committee, or another one just like it, and at a similar one on the House side, while representatives of NASA promised the Congress that each shuttle would carry a payload of 50,000 pounds into

low earth orbit at a launching cost of $100 per pound, that each shuttle would be good for 100 flights, and that the agency would be conducting 50 shuttle flights per year by the early 1980s.

Despite testimony by me and a few others expressing extreme skepticism of these claims, Congress did approve the program. But, in subsequent years, they failed to give it adequate support.

Partly for this reason and partly because of NASA's outrageous optimism, we find ourselves in the present state of massive disarray, frustration, and national trauma.

Against this backdrop of experience, I read the Report of the National Commission on Space with keen interest but with the overwhelming feeling of having been there before.

Moreover, the national situation in 1986 is markedly less propitious for an accelerated civilian space program than it was in 1969, on at least two grounds.

First, in contrast to the national pride in the Apollo program, we are now faced with much less public interest in the space flight of human crews—a waning interest further chilled by the *Challenger* disaster.

Second, we must anticipate stringent limits on funding for our civilian space program during the next decade as part of the effort to reduce the annually growing Federal deficit.

I would be delighted to see the United States undertake the full agenda of the National Commission on Space. But, as a pragmatist, I am totally unable to foresee anything other than a rather feeble effort in that direction during the next few years. Worse yet, President Reagan is politically committed to the costly resumption of shuttle flights, possibly including a replacement shuttle, and the even more costly development of a system of permanently manned space stations—all within a frozen NASA budget.

My own agenda for the near-term is realiy quite different. It recognizes the realities of our present situation and strives to revive those elements of our space program that experience has shown to be the most successful and the most important.

My agenda is as follows:

First, to suspend manned flight indefinitely, pending critical assessment of its justification. I might say that this is not a terribly radical suggestion since it is already suspended indefinitely.

Second is to postpone development of the space station.

Third is to resume the production of previously well-developed expendable launch vehicles, such as Scout, Delta, Atlas, Centaur, and Titan and upgrade their performances progressively.

Fourth is to seek lower cost launching techniques.

This, of course, is a universal desire with an unknown solution.

Fifth is to emphasize advanced applicational and scientific work.

Last is to recast the structure and the public image of NASA to those of an agency whose primary purposes are to develop space applications of widespread human importance and make major advances in human understanding of the great universe within which we are privileged to live.

But if, contrary to my expectation, Congress increases NASA's budget by 15 percent per year for the next 10 years, I will be very happy to shift my support to Dr. Paine's agenda.

Thank you, sir.

[The statement follows:]

STATEMENT OF DR. JAMES A. VAN ALLEN

Mr. Chairman and members of the committee: I am grateful for this opportunity to participate in your hearings on the future of our civilian space program.

It is courageous, perhaps even foolhardy, to go on the public record with an agenda for the next 50 years, especially in a highly technical field. For example, I have not found any anticipation of the invention of the transistor in forecasts of 50 years ago. Yet today the transistor and associated electronic techniques have revolutionized communications and computing, and have made possible numerous devices in daily use by the general public; and are of crucial importance to sophisticated space equipment.

It is easy to visualize ambitious projects in space. Such projects have been the stock in trade of science fiction writers for many centuries. With no difficulty whatever, I can think of a billion dollar space project before breakfast, any day of the week; or a two billion dollar project before breakfast on Sunday.

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In partial response to the Agnew report, NASA proposed to develop a reusable space shuttle in order to make a drastic reduction in launching costs. On several occasions in 1971 and 1972, I sat at this witness table in hearings of your committee and at a similar one on the House side while representatives of NASA promised the Congress that each shuttle would carry a payload of 50,000 pounds into low earth orbit at a launching cost of $100 per pound and that the agency would be conducting fifty shuttle flights per year by the early 1980's. Despite testimony by myself and a few others expressing extreme skepticism of these claims, Congress did approve the program. But in subsequent years they failed to give it adequate support. Partly for this reason and partly because of NASA's outrageous optimism, we find ourselves in the present state of massive disarray and national trauma.

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I would be delighted to see the United States undertake the full agenda of the National Commission on Space but, as a pragmatist, I am totally unable to foresee anything other than a rather feeble effort in that direction during the next few years. Worse yet, President Reagan is politically committed to the costly resumption of shuttle flights and the even more costly development of a system of permanently manned space stations—all within a frozen NASA budget.

My own agenda for the near term is quite different. It recognizes the realities of our present situation and strives to revive those elements of our space program that experience has shown to be the most successful and the most important. It is as follows:

Suspend manned flight indefinitely pending critical assessment of its justification. Postpone development of the space station. Resume the production of previously well-developed expendable launch vehicles such as Scout, Delta, Atlas, Centaur, and Titan and upgrade their performances progressively. Seek lower cost launching techniques. Emphasize advanced applicational and scientific work. Recast the structure and the public image of NASA to those of an agency whose primary purposes are to develop space applications of widespread human importance and make major advances in human understanding of the great universe within which we are privileged to live.

But if, contrary to my expectation, Congress increases NASA's budget by 15% per year for the next ten years, I will be very happy to shift my support to Dr. Payne's agenda.

Senator GORTON. Thank you.

Dr. DONAHUE. Thank you, Mr. Chairman and Senator Rockefeller for asking me to come here this afternoon to comment on the "Report of the National Commission on Space."

As you know, I am Chairman of the Space Science Board of the National Research Council, and, as such, I represent an organization whose special competence is in science.

So I shall confine my remarks to scientific matters, and that makes my task very simple.

We and the commission share a common perception of the goals of science, the goals that science should seek to attain during the first couple of decades of the twenty-first century.

It is not difficult, therefore, for me to endorse enthusiastically that part of the report that deals with science.

The commission identifies as the first of its major thrusts that it proposes for the civilian space program, the space agenda, as "advancing our understanding of our planet, our solar system, and the universe," and it recommends a supporting commitment by the nation to advance "technology across a broad spectrum" to assure timely availability of critical resources.

The Space Science Board fully supports these recommendations.

Furthermore, the recommendations in the section of the report that is entitled "Advancing Science' are based on the need to answer a list of questions that, as the commission said, was provided to it by the Space Science Board. Furthermore, the Board is just completing a 2-year study entitled "Space Science in the Twenty-first Century: Imperatives for Two Decades, From 1995 to 2015," which was undertaken at the request of NASA.

Jim Van Allen, here, and George Field, who is still in the audience, participated in that study, and, as the report states, the preliminary findings and recommendations from that study were used in plotting the course for space science beyond 1995 in the commission's report.

So it is not difficult to see why the recommendations in the report for a global study of planet Earth or fundamental biology, physics, and chemistry in Earth orbit or human biology in space, or in space physics, astronomy and astrophysics, and a study of the solar system are so similar to those that the Board itself is preparing to make.

You have also asked me to comment on the compatibility of the recommendations in the commission's report with national resources that may be available.

Well, if you keep in mind that the space program, during the days of Apollo, was run at three times the budgetary level to which it has been held during the past decade, I do not see any reason why the Nation cannot afford the kind of space science activity which is recommended by the commission for the first two decades of the next century.

I am not going to comment on the rest of the commission's recommendations, partly because I am here representing the Space Science Board. The decision on accepting them is not one that will be based on the scientific aspect of the report, that is, the decision on accepting the entire package.

Most scientists strongly believe that the advance of science and its applications to human welfare would provide a worthy key objective of the space program of the United States in that scientific objectives can provide any degree of challenge in the development of space technology and thus assure that scientific and engineering resources are effectively utilized in the national interest.

The scientific program in the report, "Pioneering the Space Frontier," is one that would meet those requirements.

I must confess that I am much more preoccupied by short-range concerns, as I sense so many of us are here, than with the subject you asked me to come here to address, and that is the concern of how to fix the present space program, which has been "broken" since the early 1970s, as Jim Van Allen has just pointed out, the situation that culminated in the *Challenger* accident. The problem for science and the problem for all users of the space program is acquiring access to space, and that is something that we do not have now because of the inadequacy of the shuttle to provide that means of access.

In my prepared statement, I have made specific recommendations at some length, that I would be prepared to go over with you in detail, whenever you wish.

Thank you, Senators.

[The statement follows:]

gram that is a proven failure, because it does not assure access to space to the only real users of space. Our first priority should be to obtain that assurance and that means to give precedence to the acquisition of alternatives to the shuttle. It also may mean changing the way this nation goes about doing things in space—by making huge technological quantum leaps. The only large scale space program that is working very well these days is the Soviet one. It has gotten where it is by a process of improving reliable technological systems, particularly launch vehicles and space stations, in relatively small increments. The tortoise seems to be winning the race with the hare again.

The present standdown is threatening to cause an average delay to space science and applications free flyers of about three and a half years and to attached payloads of about four and one-half years. As we all know these delays cost huge amounts of money for which we get no return in the way of scientific data. If space science is to survive these four years in the desert, ways must be found to keep scientists working on scientific space projects. Obviously existing spacecraft in orbit must be kept operating and investigations using data from them must be kept fully funded—unless it is demonstrable that the returns are not worth the effort. Suborbital programs and especially the Explorer program should be greatly expanded and extended to all disciplines of space science at once. I am thinking in terms of factors of three or so increase. The level of research and analysis programs must be augmented. There is an emergency. The nation must respond to it or lose the base for the science programs of the future. For much the same reasons it is important that we continue to make progress toward flight projects of the future. Some way of going ahead with big programs such as ISTP, AXAF, CRAF needs to be developed.

Looking ahead to the time when shuttle flights are resumed, it is also clear that a way must be found to insure access for space science and applications payloads to the shuttle along with national security payloads. Obviously serious national security needs must be accommodated first, but a firm arrangement to allocate some fraction—say one-third—of all shuttle flights to science and applications is reasonable and even mandatory.

I hope that what I have had to say does not seem unduly self-serving. My assignment is to inform you about the needs of space science. It is up to you to decide whether space science is worth preserving. I know that you gentlemen care as much about the space program as I do. I hope that we can join in calling on the nation to rededicate itself to a strong, exciting effort in space that will restore us to our accustomed place of leadership.

Senator GORTON. Thank you.

Dr. Van Allen, when you were appearing before the predecessors of this committee in 1971 and 1972, what were your recomendations for the future of the space program, for the space shuttle at that time?

Dr. VAN ALLEN. My basic position at that time was that we had a well developed stable of expendable launch vehicles—they are essentially the same list we have today—and that those were well developed and relatively inexpensive, in my judgment, compared to what the shuttle would cost, and had a level of reliability which would give us a diverse and resilient launching capability.

I also expressed very grave skepticism about the claims that were then being made by NASA about the cost of launching with a shuttle.

Senator GORTON. I take it your recommendations were simply to go on with what we were already doing with incremental improvements?

Dr. VAN ALLEN. Basically, yes.

Senator GORTON. Did that include or not include any kind of emphasis on manned space flight?

Dr. VAN ALLEN. I didn't catch your last words, sir.

Senator GORTON. Did that include or not include further manned space flight, or were you dealing exclusively with ELVs?

Dr. VAN ALLEN. I did not take a position on that either way. I have not been one of the well-known advocates of manned flight as a component of our national program. On the other hand, I have never been against it, either. I think we have to size it up pragmatically. That was the position I took at that time.

Senator GORTON. Is it your view that had we followed those recommendations in 1971 and 1972, we would be spending the same amount of money today on space that we are?

Dr. VAN ALLEN. Well, we could be. Of course, the amount that we spend is in some sense arbitrary. It is determined by your committee, among others.

I think it depends on the interplay between the advocates and the skeptics concerning what is worthwhile to do in space.

My judgment is that we have reached a kind of equilibrium of that sort. It is represented by essentially a constant budgetary level for the last 12 or 13 years. It has been almost dead flat in terms of real purchasing power or human effort.

I think the mix would have been different—let me put it that way, Senator. We would have had a much greater, more vigorous applicational and scientific program and less emphasis on the manned area.

Senator GORTON. Of course, I was not a member of this body or this committee at the time. But I am inclined to feel fairly strongly, however, that had we followed that course of action, we would not have had a steady appropriation for NASA in constant dollars, either in real dollars or in nominal dollars, but almost certainly a constantly lessening of appropriations.

I guess one of the great difficulties that we have to face is whether or not the amount of money that we can find here in the Congress drives the program or whether the dreams and desires of the program to a certain extent drive how much money we can get for it. And unless we have something which tends to both keep the interest of the American people, and to the extent that we can stretch their imaginations, I do not think we would continue to spend what we are now.

Dr. VAN ALLEN. Well, I realize that that is a question to which the answer is not known, and I have given various reasons for thinking the contrary in articles that I have written recently. It is certainly not a theorem that that is the case.

Senator GORTON. True.

Dr. VAN ALLEN. It is a judgment call which very well could be wrong.

I think that if the American people properly understood what space is really good for, there would be ample support for something like the present level of effort.

I am thinking about applications in weather, navigation, geodesy, oceanography, communications of all sorts. If all of these things were brought to the public attention properly and honestly, I think they would have ample support.

Senator GORTON. On the other hand, you did say at the very end of your testimony that you felt if we could have a 15 percent increase in space support for a year for a considerable period of time, then you would find yourself in agreement with the recommendations of this commission, which you pointed out were remarkably similar to recommendations made almost two decades ago.

I take it, therefore, that the fact that the recommendations of this commission are quite similar to those in 1969 is not a critique either of 1969 or 1986 in one sense, but a validation of both?

Dr. VAN ALLEN. Well, of course, there is a good deal of commonality of thinking.

For example, Dr. Paine was a member of both groups and Chairman of the present one. That gives one the expectation that there is some commonality of thinking.

The things that the commission has enunciated in terms of long-term goals are part of our culture. There is nothing original to the commission's report. I hope I made that clear. I can cite any number of previously published books by well-known futurists who have all these same concepts in them. It is a kind of digest under an official umbrella.

So I do not think they are necessarily either validated or invalidated by being repeated. They are repeated every day, actually, in various contexts.

Senator GORTON. I would like both of you to comment on my next question.

Can either of you give us any help or any insignt into what it would take to make the climate of public opinion in the United States more propitious for implementing the recommendations of this commission or, in any event, toward supporting a more ambitious space program than it appears we will be able to fund in the course of the next few years.

Dr. VAN ALLEN. I will try that one and I think Tom ought to have a crack at that one, too, Mr. Chairman.

It may be impossible. I think that is one answer. It might be a kind of practical answer.

I think we can sustain something like the present effort but make it much more fruitful. That is essentially my judgment of the total situation.

We can sustain an effort of this general magnitude and the American people, if properly informed, will endorse it at something like this level.

Now, the present cost of NASA's program is about $30 per year per capita. That sounds like a pretty small amount of money. But for the head of a family, it is $120. If we were to increase that three to four times, which is essentially what is proposed by the commission, we are up to $400 or $500 per family.

Again, that may or may not be judged worthwhile by the average head of a family, but I think he begins to have very grave doubts about it at that level.

Senator GORTON. Thank you.

Dr. Donahue.

Dr. DONAHUE. I tend to challenge a little bit the basis of your statement, that there is as much resistance to this program, to the space program, or lack of enthusiasm for the space program out there, as some of us perceive.

I find, as I go out and talk to the people, that they are intrigued, they are supportive of the space program.

I do not think we have as much of a problem as sometimes we believe that we do.

We have a grave problem right now because the space program is perceived as floudering, and that is an image that is difficult to erase. It is difficult to try to sell something positive in that climate. So I see our problem right now as to fix the space program, and once it is working again, I believe the American people would enthuse about even the sort of thing that the Paine Commission is recommending.

Senator GORTON. Dr. Donahue, I believe your written statement leaves the impression that you feel that one of the competing technologies for the next generation vehicle, the aerospace plane, is of questionable value.

Is that a fair implication from what you say in your written statement?

Will you comment on that in general terms.

Dr. DONAHUE. If I said something like that, I think it was in the context of priorities. My judgment is that the most important problem we face right now is getting a means of launching payloads and getting them back into orbit.

To me that says that the first priority is acquisition of expendible launch vehicles, and this means acquisition of expendible launch vehicles, such as the seven segment Titan Centaur, to launch the three major science missions that need to be launched at the end of 1989.

Now, to pay for those, if it is necessary to give up something else, I would postpone acquisition of the replacement orbiter. I would slow down or descope the space station, and I would reduce the level of activity in acquiring that plane.

I think the question of the feasibility of that plane is one that is so much in doubt right now that it is very difficult to pass a judgment on the thing. The question is whether the motor works or not.

Now much more important than getting going on that thing is finding a way to get Galileo, to get Ulysses, to get Magellan, to get the Gamma Ray Observatory—all of those missions that are already built or being built—into orbit. I do not think the shuttle is ever going to be a suitable way of launching those space craft. The only way to do it, in my opinion, is to use expendible launch vehicles. Hence that is my first priority.

Senator GORTON. I take it you would agree with that statement?

Dr. VAN ALLEN. Yes, very much, Mr. Chairman. I would add to what Tom just said that the United States has several billion dollars worth of high priority payloads in the launching queue at the present time, and

those consist of a comprehensive mix of commercial military, application of and scientific payloads.

So I join with Dr. Donahue in the feeling that the real national emergency at this point in time is to regain our launching capability. There is nothing in my judgment that competes with that at the present time as a national urgency.

Senator GORTON. Both of you of course know that the commission suggested the establishment of a White House National and Aeronautics Space Council. I would like your comments on that, whether or not you think it is particularly important or not much more than window dressing, and if you think it is potentially important, how ought it to be composed?

Dr. VAN ALLEN. I am more or less familiar with how that operated in the early days. The Vice President was the Ex-Officio Chairman of the National Space Council, and there were a number of other persons designated by law. I cannot remember the exact list, but I think it included the Secretary of Defense, the Administrator of NASA and the Secretary of State. In my judgment, it was constituted at such a high level that no one ever did anything in a cognitive sense. I think it was definitely in the "window dressing" department, although they did develop a small, but good, staff over the years which came and went and made some significant studies.

But it was in no sense effective as a board of directors of an enterprise.

Senator GORTON. Dr. Donahue?

Dr. DONAHUE. I agree with Van in his characterization of the old Council. But somethign of that sort, something like a board of directors, might be useful to the National Space Board, for example.

We need something that really would function as a board of directors and not be at quite such a high level.

I am certainly not an enthusiastic fan of the present collection of people who worry about these issues, that is the Senior Inter-Agency Group on Space. That does not seem to me like the right way to run a space agency.

Senator GORTON. It doesn't to me, either.

Gentlemen, we have kept you a long time this afternoon yet, your testimony has been of considerable help to the subcommittee.

We really do appreciate your coming.

Dr. Van Allen, it was not only good for us but refreshing for us to get a different point of view.

Dr. Van Allen. Thank you very much, Mr. Chairman.

Dr. DONAHUE. Thank you.

Senator GORTON. Thank you, both.

[Whereupon, at 4:35 p.m., the subcommittee adjourned, to reconvene upon the call of the Chair.]

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

THE NATION'S SPACE PROGRAM AFTER CHALLENGER: THE NEED FOR A REASSESSMENT OF THE ROLES OF MANNED AND UNMANNED SYSTEMS FOR LAUNCHING SCIENTIFIC SPACE MISSIONS

The Space Science Board of the National Research Council shares with NASA and the Nation a deep sense of grief over the loss of the crew of the space shuttle Challenger—seven exceptional Americans whose lives were dedicated to some of our country's loftiest goals.

At this time of national reflection following the tragedy, much thoughtful consideration is being given to the goals and the future of the American space program. We believe that these reflections on our country's efforts in space are very appropriate. *In the course of these considerations we urge that high priority be given to assessing the proper level of resources required for the nation's space program and the proper balance between manned and unmanned activities. This reexamination should assign to manned and unmanned systems and launch vehicles the roles that will permit each to serve the nation best, in contrast to the course we have been following for the past fifteen years.* The result of this analysis may call for the allocation of greater resources than we are presently devoting to the space program. It may call for better management of those resources or a mixture of both. In any case, we also believe that it is mandatory to ask whether this nation should proceed with such a highly visible, prestigious national enterprise on the frontiers of technology at an effective level of resources where the consequences of a single tragic accident can cripple the entire program, civilian and military. It is now time to determine the strength of the national will for our country's space effort, and to determine if it is our intent to pursue a pioneering program on the frontiers of space embracing a wide range of activities. If the nation concludes, as we believe it should, that such a course is in the national interest, then it should resolve to devote to that effort the means to carry it out properly.

Since 1974 the annual budget for the civilian space program has remained almost constant at about $7.5 billion, corrected for inflation to 1986 dollars. In contrast, the peak funding level in the mid 1960s—in the midst of the Apollo program—was three times as large. This substantial reduction in our space effort reflects a decision that was made at the conclusion of the Apollo program not to provide the means to undertake soon another ambitious, challenging space program similar to the one that had placed men on the Moon and returned them to Earth. Furthermore, following Apollo the nation failed to identify any clear goals for its space program, but, nevertheless, tried to attain a level of activity well above the limit set by the means that have effectively been available.

The major new program in manned space flight that was authorized during the decade of the seventies was the space shuttle, a transportation system that was meant to be the sole national means of access to space and was expected ultimately to be economically self-sustaining. Later, related actions stopped the procurement of expendable launch vehicles before the shuttle became a proven, reliable system; prevented planning for the development of advanced unmanned launch systems; and encouraged planning for two ambitious scientific missions, Galileo and Ulysses, to use the shuttle in a manner that would severely test its capability in the first attempts to launch high priority science spacecraft. These decisions had the effect of making unmanned space missions, including those of space science, dependent on manned vehicles, the shuttle in particular, in a way that caused serious problems for both aspects of the space program. This policy, which has deprived the nation of launch vehicles for major scientific payloads for almost a decade, has been devastating for space science.

The most recent launches of major science payloads requiring launch systems of the Titan-Centaur class occurred in 1977 when the two Voyager spacecraft were sent off toward the outer solar system. In the mid 1960s, scientific missions were being launched at a rate of 5 to 6 per year by the United States. A measure of the level of activity and reliability of the U.S. program before 1980 is that 9 interplanetary missions that were launched during that period are still sending valuable data from space. The Challenger accident means that at least a full decade will have lapsed between the launching of the Voyagers and the next major scientific mission by the United States. Seven full scale scientific missions have been or are being prepared for launches that were scheduled to occur during the next two years. Several others were waiting in line behind these. In the meanwhile other nations have been methodically picking up the pace and improving the quality of their scientific enterprises in space.

As a matter of highest priority in a reenergized national space program to which a realistic level of support is dedicated, we strongly urge that the nation move rapidly

toward the acquisition of a balanced fleet of launch vehicles that will provide assured access to space for all activities demanded by our national space program. The characteristics of these launch vehicles should be determined by the needs and requirements of all potential users—military, commercial, and space science. We recommend that space transportation and launch systems be expeditiously acquired that will allow human resources to be used were they are needed and can be most effective and allow unmanned vehicles to be the carrier of choice for other missions. A policy that merely provides for the use of existing commercial expendable launch vehicles would not be an adequate response to this recommendation.

In summary, it is our view that one of the most important lessons from the Challenger accident is that the objectives of a highly visible and important national endeavor such as our space program must be clearly stated, that an adequate variety and level of resources should be provided to carry out this program successfully, and that measures be taken to insure that those resources are efficiently managed. These resources should assure access to space to all elements in the space program: civilian and military, manned and unmanned. *The objectives of the manned and unmanned elements of the program should not be mixed in ways that reduce the effectiveness of either of them. To do so risks forfeiture of our scientific and technological leadership in space.*

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