WAYS AND MEANS OF EFFECTING ECONOMIES IN THE NATIONAL SPACE PROGRAM

HEARING

BEFORE THE

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

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CONTENTS

APPENDIXES

WAYS AND MEANS OF EFFECTING ECONOMY IN THE NATIONAL SPACE PROGRAM

TUESDAY, JULY 24, 1962

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C.

The committee met at 10 a.m., Hon. George P. Miller (chairman) presiding.

The CHAIRMAN. The committee will be in order.

This morning we begin 3 days of open hearings before the full committee designed to supplement our annual review and authorization of the program of the National Aeronautics and Space Administration.

The specific purpose of these hearings is to explore new methods, approaches, and techniques which we hope will provide our Government with ways of introducing savings into the national space effort.

Today, we will hear from several officials of the National Aeronautics and Space Administration. Tomorrow, our witnesses will represent both NASA and the Department of Defense. Thursday morning, the committee will hear from two of the many industrial organizations which are deeply involved in what is now called the aerospace business.

One cannot help being impressed by the enormous amounts of money which the national space program costs each year.

Equally impressive are the yearly increases in the funds needed as our Nation's space effort gains momentum. We have not yet reached a plateau where annual expenditures are sufficient to sustain the program at an appropriate level of effort, though we trust that day is not far off.

As a nation, we have already invested considerable talent and resources in the space effort. That effort is now generally accepted as a national program of key significance, and its success has become a national objective. It is therefore inevitable that still more of our Nation's wealth will be invested in the future.

The House of Representatives looks to this committee to assure that this investment is made wisely and prudently. One of the most important functions of this committee is the annual authorization of the various programs of NASA, together with the funds to support those programs.

It is well known that this session, with four subcommittees working simultaneously, the membership of the Science and Astronautics Committee spent many weeks conscientiously reviewing NASA programs and the corresponding requests for funds for the forthcoming fiscal year. Our work on the authorization bill is now almost completed.

Our work, however, does not end there. By law, the Committee on Science and Astronautics is charged with continuous watchfulness of the activities of NASA and other Government agencies engaged in scientific research and development. We do not take this responsibility lightly, and it is our intention to perform the extremely important function of overseeing the activities of the executive branch to assure that the billions of dollars of taxpayers' money appropriated by Congress each year in support of the national space effort are utilized in the most effective and the most efficient manner.

I am sure I speak for all the members of this committee when I say we believe that the United States must have a vigorous space program. I am convinced that it is the manifest destiny of this Nation to lead the world in the space age.

The national space program is an activity which a first rate nation such as the United States of America simply must pursue. There is no alternative; America must accept the challenge of the mid-20th century. Nor do we resent the costs, for we know that the space effort is an investment in the country's future which is certain to pay rich dividends.

This inquiry simply recognizes that in any program of this magnitude there must be a variety of ways of achieving greater effectiveness in the use of appropriated funds; there must be ways to assure more efficient utilization of facilities and equipment, and the development of new materials and fabrication techniques which will tend to reduce costs.

We intend to explore some of these matters with representatives of both Government and industry this week. The suggestions we receive may form the basis for additional hearings next session on the general subject of economy in the U.S. space effort.

We shall start this morning by welcoming Mr. D. D. Wyatt, Director, Office of Programs, NASA headquarters. Mr. Wyatt is accompanied by a number of officials of NASA who are responsible for various aspects of that agency's activities. Mr. Wyatt, would you be kind enough to introduce those officials to the committee at this time?

STATEMENT OF D. D. WYATT, DIRECTOR, OFFICE OF PROGRAMS, NASA

Mr. Wyatt. Thank you, Mr. Chairman.

We do have this list of specific witnesses in various areas.

I would like to make a general comment, if I may.

We at NASA are acutely aware of the magnitude of the effort that we are undertaking on behalf of the United States.

We are aware of the magnitude not only in terms of the technical implications, because this program is one which is attempting to achieve things man has never attempted to achieve before, but we are aware, moreover, of the financial implications, of the resources of the country that must be put into this program to make it succeed.

We view our program, not with pride at its cost, but with an understanding that it is an R. & D. program of possibly greater magnitude in total effort than that of any other agency of government.

Each of our projects requires the development of new components, new systems, new techniques, new ways of manufacturing, for us to achieve our ends.

Of necessity we are starting out, therefore, in almost all of our programs, with objectives to achieve, but without a clear understanding of the details of the processes by which we will get there.

We must work in this area of research and development, therefore, against a time scale, trying to do things that we are not always positive can be done when we start out.

We think they can, but it frequently involves a multiplicity of effort to get to the desired end result.

Within all this not only have we been conscious of the development of new techniques to meet time scales, but we are also conscious of the need for sucess in our operation, because, in truth, the greatest waste of money that we can pour into this kind of operation is to try things that fail, because each of our attempts, as you know, is extremely costly.

We are cost conscious, therefore, in laying out our program; we are cost conscious in the selection of the methods we use, and the witnesses that will appear before you today and tomorrow will discuss various aspects of the cost consciousness that we introduce into our basic programing.

We will talk with you about the business methods we use in the areas of procurement and supply.

This will be done by Mr. Ernest Brackett, the Director of Procurement and Supply Division here at NASA headquarters.

We will talk with you about some of the work we are doing to improve and develop new manufacturing techniques in the areas of these very large launch vehicles, which represent extensions of the state of art in terms of rocket boosters far beyond anything the world has attempted.

We shall discuss with you new approaches that we are prepared to initiate now in the launching of these very large launch vehicles to minimize the resources investment we must make in facilities and in people to accomplish the actual flights.

We will talk with you about the spacecraft utilization, how we go about designing our spacecraft and adapting to the missions so we can get the maximum utilization from development efforts.

We will talk with you about how we are trying to cooperate with and use the resources of the Department of Defense in the worldwide system of tracking and data acquisition, that element of our program which is really the key to success, since we are flying in space and must obtain all of our information electronically.

Finally, we shall talk about a new approach to the integration and checkout of the very complex systems, including the launch vehicle and the spacecraft, that are represented in a very large program such as Apollo; we think we are embarking on a program of new techniques that will insure greater reliability and hence fewer failures, and that will also insure an economy in the actual conduct of the development of this tremendous effort.

With this, Mr. Chairman, I would like, if it is the pleasure of the committee, to introduce the first speaker, Mr. Ernest Brackett, the Director of Procurement and Supply Division.

The CHAIRMAN. Before you get into that, I would like to ask you a question.

Mr. WYATT. Yes, sir.

The CHAIRMAN. Does NASA continuously review its current programs, particularly some of the new programs, to make sure that they may not become obsolescent before they get into the hardware stage?

Mr. WYATT. Yes, sir; we do have a continuous form of review process, both formal and informal, through what we call the monthly status review of particular problem areas—in fact, I left such a meeting this morning.

We review all elements of the program to see where the program is against its goals, and the problems that have arisen, and to identify areas in particular where it may be desirable to change our goals or to eliminate them.

In research and development one cannot fix in his mind for all time what the goal is to be, because, by the very nature of the business, if we make a firm decision today, something may happen, either within NASA or within the rest of the research and development community tomorrow, that sheds new light on a program and either says it should be emphasized, or should be eliminated.

There is a state of continual review of our programs to make sure that they are suitable to the facts at the moment.

The CHAIRMAN. I can visualize a situation whereby dedicated men may be assigned to a project that in the rapidly developing state of the art may become obsolete, but who would hold very rigidly to the further development of the program because of their closeness to it. They cannot see the forest for the trees.

Now, in your program reviews, do you officials of NASA take this into consideration too?

Mr. WYATT. Yes.

The CHAIRMAN. So as not to allow yourselves to be influenced by people who may say "This is the only way it can be done," when later developments show that perhaps the whole program should be scrubbed.

Mr. WYATT. Yes, sir; we do try to maintain an objective viewpoint by having enough people participate in these reviews in direct and related areas that we are not, I think, swayed by single viewpoints, single personalities, but it is weighed within the total objective viewpoint.

The CHAIRMAN. Mr. Karth.

Mr. KARTH. Mr. Chairman, I would like briefly to explore one potential problem that I think NASA, as well as most other agencies of the Government, has.

That is the sincerity or the integrity of the contractors with whom you have got to do business.

I understand that there are a great number of overruns of costs or maybe we should say there is a substantial number of underestimates, if I may call them such.

Do you care to address yourself to this?

For example, programs that start out costing $100 million many times end up costing $300 million.

Mr. WYATT. Yes, sir. This, we must readily confess, is a problem that we face almost daily.

It is a problem Mr. Brackett may be able to shed some light on, from the procurement aspect and the negotiations on the contract.

I think we find that our contractors are sincere. The fact is that we start out, when embarking on many of these projects, without a completely detailed understanding of all the steps involved to get from the start to the completion of the project.

Quite frequently the cost increases in the program are not in truth overruns in the sense of requiring a lot more dollar expenditure or manpower expenditure to do something we knew about, but rather the identification of subtasks, the occurrence of problems that we had not specifically identified that simply must be solved—that require the input of a lot more effort.

In general, I think one can get a perspective, when we talk about spending dollars, and dollar overruns, if we realize that we are really talking about buying effort on the part of the contractor, engineering as well as manufacturing effort, and in our area the preponderance of work is less in manufacturing in the sense of production.

We are trying to improve our cost forecast techniques. We have this year, for example, obtained a new step in Government-contractor relationships, with the approval of the Bureau of the Budget, whereby we have devised a system that requires the contractor to report quarterly what he has done, his expenditures, and then to project ahead, not on the whole contract, which has been the traditional method of doing business with the Government, but that he project whether the hundred-million contract is still that amount or will go up; this requires him to break that down into constituent tasks within the contract and identify each separately, so we may see, if he projects that things will cost more, what element of the task will cost more, and why that particular element is up.

This is a completely new departure in Government-industry relationships here in terms of identifying future costs.

Mr. KARTH. How long has this been going on?

Mr. WYATT. We are just instituting it.

We have had it in practice for less than a year on several major contracts and are now instituting it across the agency.

Mr. KARTH. You have gone to this new system for some reason. Would you explore that?

Mr. WYATT. The reason is, these numbers, in many of our contracts, are so very big that they must be broken down to identify exactly what is the necessity for spending money beyond the original estimate.

Mr. KARTH. When the contract is let, generally it is let on the whole project.

Mr. WYATT. Yes. I don't want to confuse you. This is not breaking the contract itself down, but the reporting against the contract. Traditionally the contractor has reported against the whole contract when he gives his estimate of completion costs. We might break it down into 100 subcosts. These are by technical task areas. We break the whole job down into a number of identifiable but fairly sizable areas, perhaps averaging 10 or 15 million apiece in a $400 million contract and ask the contractor to project against each, and some phase out when completed and new ones come in.

The reason is that we must get a handle. When one talks about a half-billion-dollar contract, it is not very manageable at a half-billion-dollar level.

Mr. KARTH. You have had that system for how long?

Mr. WYATT. We instituted it on a trial basis about a year ago, but this spring we secured the approval of the Bureau of Budget to do it throughout our contracting procedures.

Mr. KARTH. Since you made this change what percentage of overruns have you had and how does that compare prior to your making the change?

Mr. WYATT. I cannot answer that directly. I can cite instances where——

Mr. KARTH. Could you provide that information for the record?

Mr. WYATT. We can provide some of that for the record.

I would point out, the way this works, that it is in conjunction with what we call our PERT management system, which is simply the identification of the interrelationship between the literally thousands of tasks that make up a project.

We have had several occasions where the contractor has come in, has indicated that he will need more effort in a given area, but when we work between the PERT and the cost method we find in fact he may be proposing to put overtime in an area not timewise critical, and we say "No, according to your schedule you don't need to go into overtime to meet the objectives."

(The following information was furnished for the record:)

ATTACHMENT 1

The new NASA contractor financial reporting system was approved for NASA-wide use in February 1962. Prior to formal approval by BOB, NASA had installed the system experimentally on nine cost-plus-fixed-fee contracts during the first 9 months of calendar year 1961 in order to gain practical experience with the proposed system. The primary objective of the system is to improve the management and administration of cost-type contracts. It is designed to provide information to serve various management purposes including the following, which were not provided in previously available reporting systems:

1. Prediction of future possible increases in cost including overruns within the currently authorized scope of work.

2. Identification with the contract "subdivision of work" where the overrun might occur in time for corrective action to be taken.

3. Correlation of actual and predicted cost with major elements within the contract to serve as a basis for analysis of cost incurred and predictions with actual work status of jobs in process.

Whether or not savings are accomplished in a given situation is frankly a matter of judgment. First, the managing agency must obtain control of costs to be generated. In order to do this it must be informed on the actual costs and the predicted future course of the job and the costs to be incurred. Experience to date with the contractor financial reporting system is very limited both as to the span and breadth of coverage in terms of contracts. However, results obtained have been substantial. On three of the nine contracts on which the system was tried experimentally, substantial overruns and costs from original estimates were predicted through the new reporting system. In one case the contractor was directed to reorient effort in one area because of schedule difficulties in another. In a sense this produced savings of effort in terms of phasing the work by the contractor. In this case plus two others, potential overruns were spotted months and even years in advance of the time they would have been reported under other reporting systems and in time for corrective management actions to be taken.

(Because NASA feels it would be unfair to name the contractors involved publicly to whom this system was applied experimentally, the names are not mentioned. However, this information can be made available if required by the committee or its staff.)

Mr. KARTH. One last question, Mr. Wyatt.

Some contractors I suppose have greater capabilities than others, do better jobs than others.

I assume you evaluate the performance of the various contractors on a periodic basis?

Mr. WYATT. Yes, sir.

Mr. KARTH. After this evaluation, if it appears one or two or three contractors have not lived up to your expectations, what do you do about it?

Mr. WYATT. At the project level we try to work with them to correct whatever the problem might be, whether it is a technical problem or managerial problem; for example a reorganization we may think necessary within the company to do the tasks more effectively.

This in fact then extends up to the Administrator talking with the president of the company and identifying with him what it is we are unhappy with and what we want to change.

Very importantly when it comes to placing future contracts, we evaluate not only our experience but the experience of the Department of Defense with these companies and take this joint evaluation into account in placing future contracts.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Glad to have you here.

We have had sufficient successes in the united space program that we ought to look at some of the things that might be prudent.

For example, on the contract terms. For a long time I have been recommending that there be incentive-type contracts to reward people who do good work, both in research and development, as well as in launching performance operations.

Would you tell us what you are doing on that, very shortly?

Mr. WYATT. If I may defer that, Mr. Brackett was proposing to cover this in his testimony before the committee.

We can have Mr. Brackett discuss it now or wait until the statement.

Mr. FULTON. No; we will wait for the statement.

And on reliability.

That, of course, brings up inspection procedures.

I believe that we should move into automatic checkout as soon as possible on every program.

I have been to a good many launches and I see the inevitable human small error that causes tremendous results and affects the reliability of the launch.

Are you proceeding with that—very shortly. I started with 31 minutes after.

Mr. WYATT. Yes, sir.

We are acutely concerned with this problem. We are continually working with it. Mr. Sloan, the last witness who will be before you, will discuss this effort as it applies to the larger launch vehicles.

Mr. FULTON. Another problem that had struck me was, especially at Cape Canaveral, the condition on delivery of the boosters for the second stages, as well as launch equipment.

As a matter of fact, I have heard von Braun speak about boosters that arrive with 500 change orders slapped on the sides of them at the time of arrival.

Having had some experience in this kind of production in World War II, I would like to know whether you are correcting the procedures so that there are not so many modifications that are had that it ties up your pads.

Mr. Wyatt. We are attempting to, sir. We are working not only directly with the contractors where they are our direct contractors, but are working with the military services, for in most of the cases now we buy the boosters through the military.

Mr. Fulton. I would like you to put into your testimony a short statement on the development of the program management under Bellcomm, having that work as a team to advise you on bidding these programs together.

(The following information was furnished for the record:)

Attachment 2

In order to provide the necessary technical advice and assistance to NASA's Office of Manned Space Flight as required by its contract, Bellcomm, Inc., has organized its program management as follows:

1. The principal executive officers are Dr. John A. Hernbeck, a scientist, and president of Bellcomm, Inc.; and Mr. W. J. Whittaker, vice president and general manager. Dr. Hornbeck provides overall technical direction of the Bellcomm support activity, while administrative and managerial matters are directed by Mr. Whittaker.

2. Principal officers of Bellcomm's technical operating groups are Dr. W. D. Lewis, a physicist, and managing director of systems studies; and Mr. Julian M. West, an engineer, managing director of systems engineering. Various subgroups have been organized beneath the direction of Dr. Lewis and Mr. West to provide technical depth and competency.

Closely integrated technical cooperation between Bellcomm and OMSF is insured in the manner in which Bellcomm task assignments are originated and followed by OMSF. All such assignments are directed to Dr. Hornbeck at Bellcomm by Dr. Joseph Shea, deputy director for systems, OMSF; the execution of these task assignments by Bellcomm will be overseen by a technical coordinator in Dr. Shea's office.

In addition, frequent informal contacts between elements of Bellcomm's staff and OMSF technical staff members will serve to enhance cooperative efforts toward the common technical goal, and a conscientious effort is underway to insure the crossflow of technical information needed by both groups.

The relationship between Bellcomm and OMSF program management is one directed basically toward mutual cooperation in order to advance the overall manned space flight program at the optimum rate, while retaining complete management control and all final decisionmaking authority within the NASA structure.

Finally—as I have been 3 minutes already—it is rather remarkable that we don't put any penalty on the failure of operational equipment, as distinguished from research and development equipment, within 1 hour prior to launch, and, of course, the trajectory prior to orbit.

To me there are too many failures. For example, I remember five small operational failures within 1 hour prior to the Glenn launch that were small things, like a bolt breaking on the hatch when they went to close it, the power goes out at the Bermuda station, and that is the station that is to decide whether the man goes into orbit or not.

Another one was valve sticks on the loading of the liquid oxygen.

Another was the transformer box, that had to be taken out and put in.

Again, as you remember, this week, this last week, some changes had to be made, the last time, of equipment that was not up to standards of performance.

I hope you will do something on that. As a matter of fact, I would put a penalty on contractors of that type equipment, that I call off-the-shelf and over-the-counter equipment at this point in the space industry, so that they are pointed out when they make a failure, and it would be on the order of $5,000 to $10,000, $15,000, $20,000 bonds that they would forfeit on a failure of marketability or warranty of equipment or for negligence in operations.

The reason is that you cannot, from the NASA point of view, do all the inspecting, down to the nuts, bolts, screws, and the various minor items that go to make up one of these tremendous complex launch instruments.

I ask this as a question and I am through:

On the Atlas booster and the Agena—I saw it over the weekend—there was the failure, evidently, of a guidance system.

I feel that Atlas has given good service, but the thing that causes me concern is that for the Air Force on the west coast the Atlas booster seems to work at a much higher percentage of success, let us face it—and I hope I don't overstate the case—but at Cape Canaveral three out of four—I don't say three, I say four out of five, I leave one out—but three out of four of the last launches have been unsuccessful with the Atlas booster, so that the research and development equipment was lost, we never got to the point where we could make the experiment.

To me this space program is beyond that point, and we must have reliability of boosters, first and second stages.

Would you please comment on that? Is there some reason why at Canaveral 3 out of 4 losses, and on the west coast, I hate to say it, but I think it is 10 out of 11 successes.

Why is it?

Mr. WYATT. Sir, I wish I could give you a definitive answer.

I do not know.

We are concerned with this problem—because they are Atlases——

Mr. FULTON. I didn't put it on that basis.

Mr. WYATT. No, sir. We are concerned with it, we are working with the manufacturer and with the Air Force. We are taking one step, together with the Air Force, which we think may give us a better handle on this, and that is to have the boosters turned over to us after fabrication, when we are responsible for them, so we can nail down and develop our own inspection and check out techniques all the way through and have responsibility from the time of manufacture.

Mr. FULTON. I have come from the House Foreign Affairs Committee. We had to put an inspector general on that program.

Likewise the Department of Agriculture, I must say for Secretary Freeman, he has advocated and is now installing an inspector general.

Do you people need, reporting directly to the Administrator, James Webb, an inspector general that watches these things?

Mr. WYATT. We have not adopted that technique. We have, however, a General Reliability Quality Assurance Office which has promulgated recently a new set of standards that will be incorporated in our contract requirements that we think will go a long way toward solving this responsibility problem.

Beyond that we place responsibility on each program director and from time to time we do institute special investigatory boards to track these things down.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. Mr. Wyatt, I am disturbed by the large number of contracts that are let by NASA at a figure considerably above what could be done by the lowest bidder, and they turn into being negotiated contracts.

Frequently the negotiated contracts, as pointed out by Mr. Karth, result in underestimates and considerable additional expense.

The question I would like to ask is, What is your general trend over the past year or so in terms of the nature of your bidding and the bidding by strictly competitive means and by negotiated means?

Are you getting more and more of this departure from competitive bidding?

Mr. WYATT. Mr. Hechler, there is in dollar volume very little of our business that in fact we can let on true competitive bidding—that is, on a fixed price approach.

Mr. Brackett can perhaps speak to this in more detail.

Most of our efforts have to be in negotiated competition, in which price is a factor, but performance is the main thing.

This is, we feel, inherent in research and development.

We cannot let out, in general, a set of specific specifications that permit fixed-price bidding and have true competitive bidding.

In the areas of supplies, and all, we do, of course, use the competitive bidding practice and award to the lowest bidder.

Mr. HECHLER. In your negotiated competition then there appears to me, and to some members of this committee, there has been increasing disposition to look for factors other than the lowest bidder.

Mr. WYATT. Mr. Brackett, can you talk to this?

Mr. BRACKETT. I think the principal thing in research and development, particularly of items never made before, is that the emphasis has been on technical superiority rather than on an estimate of cost.

Where we make a cost-plus-fixed-fee contract, cost is an estimate, it is not fixed, as it is in the so-called fixed-price contracts.

Where we are making contracts for things never made before, such as the Mercury capsule, it would be next to impossible to get a company to take that on a fixed-price contract.

Am I right, Mr. Wyatt, that the technical superiority has been the thing that has been considered most prominently in the selection of contractors for the large research and development contracts?

Mr. HECHLER. I think we ought to get into more specifics on this later, Mr. Chairman.

I raise the general point.

The CHAIRMAN. I hope we can. I may say the points raised here can be pursued by subcommittees, perhaps at a later date.

Mr. HECHLER. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Van Pelt?

Mr. VAN PELT. No questions.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. Following up what Mr. Karth was discussing with you, Mr. Wyatt, in respect to the program outlined to check on these contracts periodically to see whether or not they are keeping up to their schedules, and so forth, the question is raised in my mind as to whether or not you have, in NASA, a corps of qualified people with the proper skills to carry out this, or to constructively follow this program of construction and these contracts.

Mr. WYATT. Sir, we think we have.

In fact, we think this is one of the major strengths of NASA in the conduct of this program—probably the largest, and we like to think one of the most qualified assemblages of technical and business skills that any country has ever amassed into a single program.

We feel deficient, we don't have as many people as we would like to have, and we are therefore exploring these techniques, this recent approach, with approval by the Budget Bureau, to permit us to dig into the subelements of the contractors' work.

They are things we are trying to do.

We think that, as nearly as any agency can, we do have the personnel.

Mr. RIEHLMAN. Are these people all on the direct payroll of NASA, or are they people hired from corporations

Mr. WYATT. These are all on the direct payroll, with the exception of the Jet Propulsion Laboratory, which is a contract with the California Institute of Technology.

Mr. RIEHLMAN. Is there any question in your mind that you are going to need additional people for this type of work?

Mr. WYATT. Unquestionably there will be some increase required in personnel as the program is developed.

At this time we are operating under the philosophy that there are elements here which can only be evaluated by and judgments made by Government personnel, rather than by a captive nonprofit contract or on behalf of Government.

We are proceeding down that road.

Mr. RIEHLMAN. In answer to a recent question about the manner in which these contracts are let, you are in the field of the unknown, and you are constructing capsules we have never had experience with before.

Mr. WYATT. Yes, sir.

Mr. RIEHLMAN. The reason I ask the question is because we are dealing with unknowns, and to get the qualified people that can follow these contracts, that have some knowledge of what NASA is after, and what these contracts ask for and require, is something that I think is very, very important and vital if we are going to pursue the contracts and know whether or not they are being carried out efficiently and economically.

Mr. WYATT. We quite agree, sir.

Mr. RIEHLMAN. That is all.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. I would like to ask this question:

You mentioned that you quite often conferred with the Department of Defense in evaluating the contractors and bidders. I wonder if you make it a policy or practice to borrow freely from the DOD's experience in procurement. Do you consult with them? I know they have had a great deal of experience.

Mr. WYATT. I will defer to Mr. Brackett. This is his area.

Mr. BRACKETT. Yes, sir, we do. We are not under the so-called Armed Services Procurement Regulations, but we do follow them as a guide considerably, and many of our people in procurement were formerly with the Department of Defense or Atomic Energy Commission, and our system of contracting, our contract provisions, and, as I will go into, our system of administering contracts, is quite closely with the Department of Defense.

Mr. DAVIS. That is all I have.

The CHAIRMAN. Mrs. Weis?

Mrs. WEIS. No questions.

The CHAIRMAN. Mr. Ryan?

Mr. RYAN. No questions.

The CHAIRMAN. Mr. Mosher?

Mr. Bell?

Mr. BELL. Mr. Wyatt, my question is also relative to liaison between NASA and other Government agencies, such as the Department of Defense, particularly in the area of technical information, which can amount to considerable sums of money if it is not handled properly.

I understand that DOD has a technical information carrier called ASTIA which they use, and it is open to other agencies. I understand further, the Department of Commerce has something of that kind.

Does NASA have anything of this kind, or do you use the information areas of other agencies?

Mr. WYATT. Yes, we use the services of ASTIA and other Government agencies. We have, however, just this past year embarked on a technical documentation program of our own of considerable magnitude in those areas of interest to us.

Mr. BELL. Mr. Wyatt, do you see any possibility of getting together with another agency and doing it jointly rather than you embarking on one yourself, or possibly joining with ASTIA of the Department of Defense?

Mr. WYATT. I would say, sir, there are complementary interests that would, I think, not make it wise to rely entirely on, or work entirely through, a single source.

We are not trying to penetrate areas that are adequately covered by the Department of Defense and other Government agencies, but in the peculiar areas that we have requirements in we do feel some documentation catalog of our own is required.

Mr. BELL. Wouldn't you think it would be an advisable factor in all economies for all agencies doing similar types of technological work to have a central library where all could participate and join in in contributing and taking out information?

Mr. WYATT. Yes, sir; I cannot dispute your basic premise. This is one of the major problems that faces scientists and technicians, however, in or out of the Government, the matter of keeping abreast of and being informed on efforts done by others.

For example, it comes to mind, in an area that we are not too directly concerned in but which I happen to have heard some figures on, the area of biology alone, there are some 30,000 separate journals throughout the world, technical journals, covering the area of biology.

I am sure in the basic physical sciences there must be comparable numbers. There are numerous papers published independently, not in journals. This, as you probably are aware, is one of the problems of our times, information is growing at such a rate that to keep abrest is very difficult.

Whether this can best be done in one supercataloging library or be done with a little more discrimination as to the specific sphere of interest is, I think, not a resolved question.

Mr. BELL. It could save a considerable amount of money and effort if, for example, you organizations particularly delving into outer space, the Air Force and yourselves, or DOD and yourselves, could jointly do this.

Wouldn't that result in considerable saving?

You could do this, could you not?

Mr. WYATT. I am not technically able to answer. We could supply a statement.

Mr. BELL. I would like to have that information for the record.

Mr. WYATT. Yes.

The CHAIRMAN. I suggest that you do that.

(The following information was furnished for the record:)

ATTACHMENT 3

NASA, in developing its scientific and technical information program, is working closely and directly with the Department of Defense and the Armed Services Technical Information Agency, as well as with other Government scientific information activities, to insure the highest possible degree of compatibility and economy in all areas of mutual concern.

With ASTIA, in particular, the closest possible working arrangements are maintained. Cataloging and document processing procedures, indexing vocabularies, specialized products and other aspects of service are under collaborative review and development, with the aim of avoiding any unnecessary duplicative effort. This collaboration recognizes the similarities between the two systems, but also allows for their fundamental differences, since one—ASTIA—is concerned with all U.S. military requirements and the other—NASA—deals with aeronautical and space science in worldwide terms.

With the Department of Defense generally, joint NASA-military information services are being undertaken whenever specific requirements dictate. Examples are a joint technical library facility to serve NASA's Marshall Space Flight Center and the Army Ordnance and Missile Command at Huntsville, Ala.; and joint support for such specialized information activities as the Solid Propellant Information Agency and the Liquid Propellant Information Agency.

The establishment of a single joint information center or library for both NASA and the Department of Defense—or, as sometimes proposed, a single information center for all Government scientific concerns—would go far beyond any present cooperative arrangements. It would require a massive central service capability; dollar economies might well be possible in some phases of the activity, although truly comparative costs between such a completely centralized operation and the present cooperative arrangements would be extremely hard to establish.

Far more important than direct dollar economy, however, would be the functional hardships imposed upon the technical programs of participating agencies. Differing needs, interests, and procedures would all have to be subordinated to common standards and procedures of the central facility. The detrimental impact of necessarily standardized procedures on many rapidly changing scientific and technological programs would be severe. While this impact would, in its turn, be extremely hard to assess, it would greatly offset any monetary saving, and might risk far greater indirect loss.

This risk would exist to some degree even if a central facility could provide timely service in response to the tremendous number of specialized requests that would be levied upon it. If, because of huge workloads or procedural difficulties in input and output, a central facility did not achieve timely service, the direct and indirect loss through duplicative research and development, or through inadequate knowledge of new techniques or findings, could quickly become critical.

It should be noted that the present programs of NASA and the Department of Defense deal primarily with technical report literature in their in-house operations. Both rely heavily upon the abstracting and indexing services of professional societies and other private interests to cover the tremendous bulk of formally published scientific information. NASA in some degree, and the Department of Defense to a probably larger extent, also relies upon a variety of spe-

90751—62——2

cialized information activities like those mentioned earlier: the Solid and Liquid Propellant Information Agencies.

To try to bring together all these varied capabilities into a single, centralized information function is not considered a feasible undertaking. Rather, continuing intensive efforts to establish effective cooperation and nonduplicative linkages in the existing scientific and technical information network of the Government and the Nation is considered the most practical course to assure both maximum dollar economy and the rapid technological progress upon which the national interest so heavily depends.

Mr. CORMAN. No questions.

The CHAIRMAN. Mr. Downing?

Mr. DOWNING. Mr. Chairman, I share Mr. Fulton's concern about the cost of our failures.

What was the cost of the Venus shot that failed last Saturday?

Mr. WYATT. Total cost, I would say, approximately in the $12 to $14 million range, between $8 and $9 million for the launch vehicle and the remainder in the space craft.

Mr. DOWNING. What caused that failure?

Mr. WYATT. As of this morning we had not definitely ascertained. Something in the guidance control of the launching Atlas vehicle.

Mr. DOWNING. Who was responsible for that?

Mr. WYATT. I don't feel that I can pinpoint a single "who."

The manufacturer is the General Dynamics Co. They are launched for us by the Air Force. I cannot at this time say a single point of "who" is responsible.

The CHAIRMAN. Who does the inspection for the Air Force?

Mr. WYATT. Themselves. The Air Force has their own inspection services.

Mr. FULTON. The guidance and control subcontractor was the General Electric Co. while the General Dynamics was the overall contractor, isn't that correct?

Mr. WYATT. That is correct. I feel it would be grossly in error to try to pinpoint at this time who is responsible.

Mr. DOWNING. I don't want you to blame anybody.

I am trying to get down to why these failures occur as often as they do.

I think we can explore that later.

The CHAIRMAN. Mr. Pelly.

Mr. PELLY. Mr. Wyatt, as I understand, one of the areas of excessive cost as against the estimates is the change order.

Mr. WYATT. Yes, sir.

Mr. PELLY. I understand that this is looked upon by many bidders as a place where they can recoup losses, where they have figured too closely under competitive bids, and I understand, too, that in this area is where there is great waste and likewise an attractive settlement.

My question is as to what the experience of NASA is as far as adjusting the disputes that arise over change orders, and what your experience has been with regard to waste in that area?

Mr. WYATT. Mr. Brackett may be able to speak to our actual expense in the field of change orders. I think it would be erroneous to draw too blanket a conclusion, that change orders are synonymous with waste.

Again, we are starting out in most cases with ill-defined detail as to the final end result.

The change order is everything from specification on a particular nut and bolt to changes up through whole basic approach design concepts which we find as we go down the road are not right and we must change to something else.

In terms of the moneys paid to the contractor in these contracts, we are working on a cost plus the fixed fee and the question of gain to the contractor comes only in whether or not he can claim the change order is outside of the original scope of the contract and hence entitled to a profit on the change, or whether it is still within the basic scope of the contract and we will reimburse him for the cost of the change but not pay him a profit.

Mr. Brackett, could you comment beyond this in terms of our actual experience?

Mr. BRACKETT. Changes originate in two manners.

Sometimes the contractor comes in and suggests a change, which he is not allowed to make until it is reviewed by the NASA engineers and is ordered changed.

At other times the NASA engineers decide themselves that a change is necessary.

As Mr. Wyatt said, if this is an actual change in specifications, something different than originally ordered, then the contractor, assuming it is a cost-plus-fixed-fee contract, is entitled to an additional fee under the terms of our contract, on the basis of the additional cost of the change.

Many of the so-called changes are not specification changes but are within the scope of the contract where he gets no additional fee.

I think perhaps the types of changes that are sometimes known, or sometimes alleged to have been unnecessary, come largely in the fixed-price type of contract rather than in the research and development.

Mr. PELLY. Do you have an accumulation of unsettled disputes in this area?

Mr. BRACKETT. I can't tell you, sir, how many disputes there are.

NASA has its own Board of Contract Appeals to which these disputes are taken and adjusted if there are disputes.

I do not believe there have been a great number of disputes.

Mr. PELLY. I can understand, of course, that if there is no loss to the contractor himself he is not going to argue, but in the cases, I am sure you have some, where the low bidder is given the award, and if in that competitive field you have contractors go in and take a very close contract, maybe lose money, and then in the change order they see an opportunity to recoup those losses—I think that experience has shown this to be quite prevalent in defense contracts.

Mr. BRACKETT. I think you are right, sir, particularly in, let us say, construction contracts, that sort of thing.

Mr. PELLY. Would you just put in the record what the accumulation of disputed items are as far as change orders that would cost the Government money have been?

Mr. BRACKETT. I will have to get that information. We will supply it.

(The following information was furnished for the record:)

ATTACHMENT 4

Based on the information in the hearings before the Committee on Science and Astronautics the information requested for inclusion in the record is considered to apply to those cases that have been submitted to the NASA Board of Contract Appeals for adjudication.

In most of those cases where the contractor is required to perform additional work in accordance with the provisions of the "Changes" clause, an equitable adjustment is agreed to by the contractor and the contracting officer and the matter never becomes a dispute.

In those situations where an equitable adjustment cannot be established, failure to agree becomes a dispute concerning a question of fact within the meaning of the "Disputes" clause of the contract. Under the "Disputes" clause, the question of fact is decided by the contracting officer, who reduces his decision to writing and furnishes a copy thereof to the contractor. Such decision becomes final unless, within 30 days from the date of receipt of such copy, the contractor appeals such decision to the Administrator. In the event of an appeal the case is submitted to the NASA Board of Contract Appeals. Following is a list of cases that have been submitted to the Board of Contract Appeals involving claims by contractors for additional amounts as a result of disputes under the "Changes" clause:

Cases on which a decision has been rendered

C. P. Wright & Co.—Contract No. NA 3-2698(w):[1]	
Contract amount	$69, 783. 00
Contractor's claim	770. 74
Claim allowed	304. 64
Cristopher Construction Co.—Contract No. NA 3-2956:[1]	
Contract amount	37, 240. 00
Contractor's claim	[2] 5, 203. 89
Claim allowed	4, 653. 89
Baldwin-Linma-Hamilton Corp.—Contract No. NAS 3-386:	
Contract amount	304, 607. 00
Contractor's claim	1, 300. 00
Appeal denied.	
Industrial Construction Co.—Contract No. NA 1-2377 and 2389:[1]	
Contract amounts:	
NA 1-2377	173, 252. 89
NA 1-2389	179, 411. 07
Contractor's claim:	
NA 1-2377	75, 197. 11
NA 1-2389	143, 005. 67
Total	218, 202. 78
Board action (claims in amount of $179,412.33 were dismissed):	
Following claims were allowed:	
Claim IV: Contract NAS 1-2389	[3] 5, 455. 00
Claim VI: Contract NAS 1-2389	[3] 5, 460. 00
Claim VIII: Contract NAS 1-2377	[3] 21, 975. 00
Claim IX: Contract NAS 1-2377	[3] 5, 900. 00
J. D. Dermody Co. & Ralph Welker, Inc.—Contract No. NAS 4-80:	
Contract amount	106, 900. 00
Contractor's claim	727. 87
Appeal denied.	
Humphreys & Harding, Inc.—Contract No. NAS 5-9(w):	
Contract amount	2, 599, 579. 00
Contractor's claim	[4] 35, 000. 00
Claim allowed	19, 000. 00
Associated Piping & Engineering Co., Inc.—Contract No NAS 3-107 (w)-PB:	
Contractor's claim	169, 214. 80
Claim allowed	49, 230. 00

[1] These are NACA contracts and were entered into prior to the establishment of NASA on Oct. 1, 1958.

[2] Reduced to $4,653.89 during proceedings.

[3] These were the amounts that were claimed by the contractor and allowed by the Board in principle but not in amount. All claims are yet to be settled based on accounting and a final amount has not been determined.

[4] Approximately—a total of 3 claims were submitted under this contract and were handled as 1 action by the Board.

Cases pending before NASA Board of Contract Appeals

Carpenter Construction Co.—Contract No. 1–13247(w):[1]	
Contract amount	$450,925.11
Contractor's claim	39,053.56
Norair Engineering Corp.:	
Contract No. NAS 5–450:	
Contract amount	1,589,125.00
Contractor's claim	2,398.95
Contract No. NAS 5–844:	
Contract amount	2,366,335.00
Contractor's claim	27,635.96
Contract No. NAS 5–2117:	
Contract amount	264,694.00
Contractor's claim	23,000.00
G. A. Karnauas Painting Co.—Contract No. NAS 3–1306:	
Contract amount	10,066.25
Contractor's claim	10,000.00

[1] These are NACA contracts and were entered into prior to the establishment of NASA on Oct. 1, 1958.

The CHAIRMAN. Mr. Waggonner.

Mr. WAGGONNER. In cases of disputed contracts here, NASA, having their own in-house capability and mediation board, they would be held to the provisions of the public law in settling contractor disputes the same as the Department of Defense, would they not?

Mr. BRACKETT. Yes, sir; the statute and the terms of the contract.

Mr. WAGGONNER. Talking about the point Mr. Karth raised, that there were overruns, and there will be as long as this program develops as it is, is there some sort of in-house program reporting system which reflects not only manpower but dollars and cents from day to day as these overruns appear, that you might be able to detect that?

Mr. BRACKETT. yes, sir.

Mr. WYATT. Not day to day but monthly.

Mr. WAGGONNER. Is there a joint responsibility between the contractor involved and NASA in reporting this that one might check against the other?

Mr. WYATT. Basically we are now beginning to put the provisions in our contract that the contractor must supply this data.

We have no way of independently arriving at his cost. We can audit his costs.

Mr. WAGGONNER. That is the point I make. Could we detect the fact these overruns are beginning to appear a little bit early if NASA went ahead and checked these things on their own to see whether or not the contractor is not holding back information?

If they had a progress reporting system, or checking system, of their own that reflected manpower and dollars overrun, wouldn't it reflect the accuracy of what the contractor is doing?

Mr. WYATT. We do independently check and in many instances have turned up potential overruns; that is, overruns that the contractor has not reported to us yet, which we sit down with him on and nail down.

Mr. WAGGONNER. Don't you feel there would be something to gain by shortening that interval from a month to a weekly period, perhaps, which would reflect day to day properly?

Mr. WYATT. I think you are reaching a point of diminishing returns. What we are doing now is moving from essentially no specified time of reporting into quarterly reporting and then into monthly reporting.

I think one would reach a point of diminishing returns on a day-to-day basis.

Mr. WAGGONNER. You have to be able to judge that.

The other thing is not so much in the form of a question as it is a comment.

Mr. Fulton raised the point, and Mr. Downing to a certain extent, too, they felt there might quite possibly be some wisdom in attaching a penalty to failure for a contractor.

I would like to point out that we ought to think a long time before we do that, because those contractors will add the cost of the penalty back, and we will pay for it one way or the other.

That is all I have, Mr. Chairman.

The CHAIRMAN. Thank you.

Mrs. Riley?

Mrs. RILEY. Sir, I am sure that Congress is happy to authorize and appropriate the money necessary for this vital program. My question has to do with what recourse do you have in the event of a strike of the employees?

Mr. WYATT. Our employees?

Mrs. RILEY. Contractors' employees. You made a contract. There is a strike.

What recourse do you have to protect the people of the United States against a strike by the contractors?

Mr. WYATT. I don't know that we have any special recourse beyond the mediation services of the Government.

Mrs. RILEY. Don't you think you should have?

If the Government makes a contract it sticks by it. I expect the contractors to do the same.

When we have a strike, as is a potentiality, what recourse do the people of America have, or do you have, against such a gesture on their part? Do you have any?

Mr. WYATT. We have none beyond the normal processes of the mediation boards of the Labor Department.

Mrs. RILEY. Then you will come back for more authorization to cover that strike; is that right, sir?

Mr. WYATT. There could be instances where our costs go up as a result of settlements arising from strikes, yes.

Mrs. RILEY. That is a little bit embarrassing for the people of America.

The CHAIRMAN. Thank you, very much.

Mr. Daddario.

Mr. DADDARIO. No questions.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. I have been concerned over the shortage of reactors, which I believe is the bottleneck in holding back our nuclear power development program.

I would like someone later to comment on that.

Next, I am concerned about where we go from here on the Mariner-Venus shots.

We have equipment for the second one and beginning about last Friday, we have a 51-day window within which we can get shots off to Venus without waiting a 2-year period.

I understand that the time to prepare the pad is about 25 to 26 days, and that would mean that we would be somewhere in August, and just a little after the middle of the optimum time within which to make a shot to Venus.

I have been a big booster for the Venus shot, as you know, right straight through for about 3 years.

It was quite a disappointment we missed in the race with Russia.

Do you intend to go ahead and put every possible speed on the next Mariner-Venus shot so that we do try to compete with Russia and get there first?

I think the first shot to a planet is a tremendous gain in prestige and a tremendous advance in science, and to have it fail on the basis that the guidance equipment goes out—after it looked to me like a perfect launch, last Sunday morning, was, honestly, to me a tragedy of the loss of a kingdom for the want of a horseshoe nail.

Now, under those circumstances could you comment on your next Venus-Mariner shot?

The CHAIRMAN. Could we put that in the record?

Mr. FULTON. Very shortly.

The CHAIRMAN. We are running behind.

We have four witnesses to hear.

Mr. FULTON. I would like the question answered shortly.

The CHAIRMAN. Suppose you put it in the record.

Mr. WYATT. Very briefly, we are proceeding, as Mr. Fulton has suggested, we are proceeding to get this launch off.

The only hitch we would see now is if a correction required as a result of this failure would be pressure enough to push us beyond the firing window.

The CHAIRMAN. Hereafter we will adhere strictly to the 5-minute rule.

Mr. FULTON. If you feel I am taking too much time——

The CHAIRMAN. Please, Mr. Fulton.

Mr. Wyatt, your next witness, I believe, is Mr. Brackett.

Mr. WYATT. Mr. Brackett.

Mr. FULTON. If the questions are not apropos, that is different, I think you make it very unpleasant all the time.

The CHAIRMAN. I will not argue with you here. I think the rest of the members of the committee have a right to time. I am trying to see they get it.

Will you proceed, Mr. Brackett, please.

STATEMENT OF ERNEST W. BRACKETT, DIRECTOR, PROCUREMENT AND SUPPLY, NASA

Mr. BRACKETT. During the past fiscal year approximately 85 percent of NASA's total appropriated funds were spent, or obligated to be spent, by contracts.

The predictions are that this percentage will go up to approximately 90 percent during the present fiscal year. It is therefore apparent that a substantial factor in how well NASA safeguards the spending of its funds is how well it performs its procurement functions.

NASA's contracts are very largely in the area of research and development; somewhere near 83 percent of its total contract dollars are spent in this field. We contract for the development of things which have never been made before, such as the Mercury capsule in which Colonel Glenn made his orbital flight.

There are no specifications or past cost experience for such things. Therefore, thus far, the type of contract which has been used to procure this type of item has generally been the cost-plus-fixed-fee form and probably it will be in many instances in the future.

Approximately 82 percent of the total dollars obligated the last 6 months of 1962 calendar year were obligated by cost-plus-fixed-fee contracts.

While this form of contracting may not be conductive to give contractors much incentive to save money, we are trying to find methods by which contractors will have incentives to save NASA funds and at the same time to develop and produce space vehicles, satellites, and other items which will render superior performance.

Mr. Webb has set up a group to study this problem. One thing this group hopes to accomplish is to find the incentives which can be written into contracts, ways that will reward contractors for saving money and doing a superior job.

The key to a good cost incentive contract of the type generally used is being able to fix fair targets below which a contractor can be rewarded by an extra fee or profit or above which he will be penalized.

To fix such targets requires an accumulation of past cost experience, and so far we have accumulated little experience. If the cost target is fixed too high the contractor may reap a windfall profit.

Performance incentives require clear definitions of performance targets and standards for testing performance. These also, in items in the early development stage, are difficult to establish.

However, the group studying these problems is hopeful of finding methods to give contractors incentives to get the maximum return for NASA dollars. It is hoped that incentive contracts will be used on a selective basis in the future.

Another thing the group expects to do is establish a system of evaluating contractors' general performance. Did a company produce a technically satisfactory article at a reasonable cost and deliver on time?

Such evaluation may be used as a basis for future contracting with a company and fixing its profit. This system itself will be an incentive.

We are now negotiating a contract, after obtaining competition, with Bendix Corp., to operate five stations of the Project Mercury tracking network.

One of the terms which has been agreed upon is a provision for an incentive fee if the services performed are superior. Each quarter the past quarter's performance will be evaluated and if, in the opinion of NASA, the services have been superior an additional fee for the following quarter may be awarded.

The base fee is approximately 3 percent of estimated costs and the additional fee, percentagewise, could go up to approximately 7 percent. So far as we know this is the first time such an incentive provision has been included in a Government contract.

NASA, of course, uses the formal advertising method of procurement for purchasing wherever it can, where standard items or services are being purchased or where detailed specifications can be drawn.

Regardless of the method of procurement, advertised or negotiated, the basic rule of our procurements is to obtain competition whenever it is possible.

The extent of competition NASA contracts have generated is at times astonishing, and competition is one of the best means of obtaining fair prices or estimates of cost.

Our policy is not to construct or provide industrial facilities if it can be avoided. NASA has contracted for large amounts of liquid hydrogen. While this may be called a commercial item there is a very limited commercial market.

However, we have been successful in making our contracts on terms which require the contractors to invest their own money in construction of plants.

May I say that in the first 6 months of the last fiscal year, 20 of our largest hundred contracts, prime contracts, were placed with small business companies.

Last week we concluded our fourth contract for liquid hydrogen and the contractor must invest approximately $20 million of its own fund in a plant and delivery equipment.

In each of the preceding contracts the contractors have fully financed their plant and equipment. This method avoids the use of appropriated funds for constructing facilities and in the long run we believe will be more efficient and save the Government money.

After NASA has made a contract it must be administered during performance. This, in the case of the larger contracts, means auditing vouchers, approving subcontracts, keeping accounts of Government property, inspection of items, approving overtime and performing such function at the contractor's plant. This requires a substantial staff of Government personnel.

In most of the plants where our large contracts are placed one of the military departments already has such staffs. To avoid duplicating these staffs we have arranged with the military departments to do most of the in-plant contract administration work for NASA. This saves funds and additional Government personnel and also confusion to the contractor.

An exception to this arrangement is where NASA has a large preponderance of the contract work in a plant and where the importance of the contracts to our program is such that it is felt direct control of contract administration is imperative. Thus far, the one time this has been done is at the North American plant where NASA has contracts for development and production of the second stage of the Saturn vehicle and the Apollo capsule. These represent approximately 85 percent of the work in the plant.

Where another Government department is already contracting for an article NASA needs, we request that it buy the item for us. An example is the purchase of Atlas boosters by the Air Force. Approximately 25 percent of the NASA dollars spent by contracts is channeled in this way.

This saves duplicate contracting, usually secures a better price because of the added quantity, and avoids disrupting delivery schedules.

The fees paid to contractors under cost-plus-fixed-fee contracts, are considered fair and reasonable. The average fee is about 6.5 percent. Our contracts are for research and development, and there are no large follow-on production contracts where contractors usually make their large dollar profits.

NASA has taken steps to obtain excess facilities or items not in immediate use from other Government departments rather than purchase new items. These items include such things as machine tools, transportation equipment, electric systems and components, and ground-handling equipment.

Thus far such facilities and items valued at approximately $6 million have been so obtained without reimbursement. The military departments have been very cooperative in furnishing such equipment which they are not using. We are constantly screening surplus and excess property lists. Last year we obtained a total of $13,400,000 worth of property from other agencies on a nonreimbursement basis.

We also have agreements with each of the military departments under which we can obtain permission for our contractors to use industrial facilities in contractors' plants belonging to the military departments.

Such use is authorized on a basis of not interfering with the use of such facilities on their contract work. By this means we avoid the necessity for duplication for our programs and thereby save millions of dollars.

NASA research centers carry a substantial quantity of supplies for use in their in-house laboratory work. Marshall stocks some 50,000 line items and other centers lesser numbers. We have placed in effect methods of handling and issuing stocks, accounting for property, and reprocurements which will save substantial sums of NASA funds.

Instead of frequently procuring low-cost items such as bolts and washers, we buy perhaps a year's supply at a time, however, taking care not to overstock. This saves the cost of numerous procurements. On items where the cost is high we buy sparingly so as not to tie up large amounts of money and save stock-carrying costs. This is a stock-management method used by many commercial companies and recommended by the GSA, who have been helpful to us in establishing this system. During the first year this method was in operation a reduction in the value of inventory at five centers was achieved of approximately 10 percent although the volume of supplies issued increased 25 percent.

Another step taken is the elimination of detailed stock recording of low value items which constitutes 85 percent of items carried in stock. This saves over 50 percent of the volume of issuing documents previously used and reduces the number of personnel employed. We also are eliminating excess stocks in our warehouses which ties up money and releases space for other purposes.

The Marshall Center increased its annual issuance of stock in dollar value by 25 percent from fiscal year 1961 to 1962 and at the same time reduced its personnel 10 percent. We have reasonable expectations that these steps in NASA supply management will mean a savings of several million dollars a year.

In its procurements of complex and advanced systems, such as the Saturn vehicle stages, and the Apollo spacecraft, for example, NASA places heavy emphasis on thorough advance planning and careful contractor selection.

In any procurement for research and development exceeding $1 million a formal "procurement plan" is prepared. In the $1 to $5 million range these are approved by the center director, such as Dr. von Braun at Marshall Space Flight Center. Those in excess of $5 million require approval of the Associate Administrator, Dr. Robert Seamans.

These procurement plans, prepared by the buying office, describe what is being procured and set forth, among other things, the proposed method of procurement, the type of contract to be used, a list of companies to be solicited for proposals, use of a board to evaluate proposals, any unusual or significant factors in the requirement or procurement, and milestones in the procurement process.

These plans are forwarded to NASA headquarters where they are reviewed by appropriate technical, legal, and business offices; changes are made if found necessary, and then are submitted to the Associate Administrator for final approval. The plan then becomes the "charter" for the procurement.

Where competition is to be obtained and almost all of them do, each plan provides for the establishment by the Associate Administrator of a board to evaluate proposals and report its findings to the Administrator, Mr. Webb.

The Board comprises of top-level technical and business personnel from NASA field installations and headquarters, as well as from any other Government agency which has particular knowledge or background to contribute.

The Board establishes criteria by which the proposals are to be evaluated, such as past experience, organization to perform the contract, technical approach, costs, facilities, and other key factors. These criteria are set forth in requests for proposals which tell companies the salient factors on which their proposals will be evaluated but do not specify the weight given the factors.

When proposals are received, they are studied in depth by the Board, in accordance with the previously established criteria. Firsthand information is obtained and checked from resident auditors, plant representatives of other departments on costs, workload, past performance, and so forth.

Upon completion of its review, the Board appears before the Administrator, Deputy Administrator, Associate Administrator, and key members of his staff, and reports its evaluation findings. Selection is then made by the Administrator after consultation with the Deputy and Associate Administrators.

We believe that this process enables NASA to obtain the most competent contractors. At the same time—and this has been stated by contractors who have lost in this type of competition—it affords all companies a fair and objective evaluation of their proposals at all echelons through the very top NASA management.

However, we are studying this system to see if it can be improved and simplified to eliminate excess cost of proposal preparation, and the time required for evaluation, but at the same time afford fair competition to any company which wishes to compete for NASA contracts.

Each year since its inception the dollar amount of NASA's contracts has approximately doubled. It is foreseeable that it may in time be contracting for more research and development than any Government department or agency. It is doubtful whether we will, in the foreseeable future, contract for items in production quantities except in a few instances.

We are trying to improve our methods of contracting and to devise new approaches, particularly in the field of research and development procurement, but at the same time taking advantage of past experiences.

We want to bring more contractors into the program and to spread our contract work over a wider range. This, we believe, can be done particularly in the subcontract area which will be especially beneficial to small business concerns and at the same time stimulating to our program with new technical approaches.

Last week we obtained informal approval from the Bureau of the Budget to institute a simple system of reporting by postal card to show where out subcontracts, through the second tier, are being placed under the larger prime contracts. This will give us a better picture of subcontracting so we can see what should be done to improve the subcontract system.

Our procurement aim is to get the best performance that can be obtained for the things we are buying and at the same time carefully spend the funds that are appropriated by the Congress for this program which is so important to the Nation.

The CHAIRMAN. NASA then is making efforts to apply the experience that it has had to the future, without being bound by the past, in trying to establish a system of procurement that is most beneficial.

Mr. BRACKETT. That is correct.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Why are so many contracts given to so few States, and what are you doing to correct it?

Mr. BRACKETT. Well, sir, one of the things that has to be considered is where the companies are located that have the facilities and the equipment and the experience, staffs and personnel to do the work.

Mr. FULTON. As long as you just negotiate with those companies on prime contracts, which you have said here, and hope that you can get a broader spread on subcontracts, that exclusive method of dealing is going to continue, that the majority of your budget now goes to five States.

What are you trying to do to correct that on the prime contract level?

Mr. BRACKETT. We try to give all companies that are interested an opportunity to compete and then pick the company that appears to have the best chance of successfully doing the job for us.

Mr. FULTON. It is getting to be a mighty small group of companies that are getting these hundreds of millions of dollars of prime contracts, and they get one right after the other.

How do we break that chain?

Mr. BRACKETT. It is a difficult thing to do.

Mr. FULTON. The other point is this: We are now having NASA teams scour the various cities—for example, my hometown of Pittsburgh—for the best talent they can get, and move them off to these five States.

If this continues and a majority of the scientists, technical people, and people experienced in all the sciences, are taken away from all the other cities, don't you think that is a bad thing for the U.S. economy and that NASA should stop it?

Mr. BRACKETT. This, sir, I take it, is where NASA is trying to hire people?

Mr. FULTON. Yes, with teams going to the various cities.

Mr. WYATT. If I may comment on that.

Mr. FULTON. We are concentrating in the few areas where not only the billions of dollars of NASA are going, but in one State, California, 44 percent of the Department of Defense research and development budget likewise goes.

What do you do to correct that?

Mr. WYATT. I don't know that we can promise any positive steps, sir.

In this instance, we are, I believe, the victims, if you will, or followers, if you will, of the policy built up in the aerospace industries by the Department of Defense.

The probability of technical success, one of the major elements in the evaluation of contractors, and time, has determined where these contractors are located that have the capacity to handle these very large jobs.

Mr. FULTON. Here is the State of Pennsylvania, pays 10 percent of the taxes and has about 10 percent of the citizens of the United States—less than that—and we do not have one NASA employee listed, out of the total of 19,000, in Pennsylvania. Why is that?

Mr. WYATT. I cannot say, sir, other than that our laboratories are located at some 11 installations around the country and outside of these laboratories we have almost no NASA employees, except a few in residence as contracting personnel, actually, at manufacturer establishments.

Mr. FULTON. In conclusion, I believe this is such a large industry it should be spread equitably among the States of the United States so that each one gets the opportunity to develop and that your policies hereafter should be to correct these gross inequities and see that the general States of the United States and the cities are not made barren of scientific personnel and everything centered in just a few favored States through negotiated contracts.

That is all.

The CHAIRMAN. Mr. Karth.

Mr. KARTH. Mr. Brackett, pursuing Mr. Hechler's line of questioning, followed briefly, I wonder if some agencies of Government are not perpetuating the negotiated bid rather than attempting to establish competitive bids by the criteria that they lay down on occasions for contractors to meet.

It is common scuttlebutt around here that a contracting officer, for example, will get himself in less trouble by picking a well-known, nationally advertised firm, as a prime contractor, because if they make a mistake it is kind of apparent that the mistake was unavoidable; but if, on the other hand, they pick one not quite so well known, not nationally advertised, does not have this public image or the good reputation, and if they should make a mistake, then the contracting officer or his associates may have to share that responsibility and that blame.

I say, this is kind of common scuttlebutt around here.

I wonder if you could address yourself to this for the benefit of the committee.

Mr. Brackett. Well, sir, I feel that our contracting officers are trying to pick the best company they can. You all know that our system of contracting for anything over a million dollars the contracting officer does not pick the contractor. Anything over $5 million goes up to Mr. Webb. He does not pick them except with the concurrence——

Mr. Karth. Let me correct my statement and say, whoever is responsible, someone picks the contractor in that way.

Mr. Brackett. I seriously question it, sir.

Mr. Wyatt. We would prefer to feel, and our experience has been, that we are making a legitimate and concerted effort to pick the best total competence to perform our tasks, in the selection of our contractors.

Mr. Karth. How many of the big prime contracts, for example, are let to subcontractors by the prime contractor?

Mr. Wyatt. Very large fractions of the prime contract goes out. We do have to approve the first tier subcontract—they are approved by NASA.

Mr. Karth. So the selection of a prime contractor is not quite as important as you might be led to believe because they do a relatively small part of the overall work.

Mr. Wyatt. Sir, in terms of the manufacturing volume—to use that word in this business—you are correct, but in terms of placing the engineering responsibility, technical responsibility, for the success of the things that are bought, the prime contractor carriers an enormous role.

Mr. Karth. So, a contractor who has, say, a thousand engineers, just for the sake of the argument, in all probability will get a prime contract just because of this in-house professional capability, as opposed to another contractor who has a hundred engineers.

Mr. Wyatt. No, sir. This is not the basis of selection. We do look at the resources of a company, but we make our own evaluation and check the company's evaluation through one of the items they submit as to how many people it takes to do the job.

We are not, let me assure you, interested in carrying on our payrolls—that is, on our contract rolls, large numbers of engineers that are not being used directly on our work, and so that while the potential of a company in an uncertain area is evaluated, whether it has the inherent strength to take on an uncertain task, it is by no means a question of automatically giving weight to a company with a lot of engineers, because they may not be needed on that task.

Mr. Karth. Do most of these prime contractors oversee the work of the subcontractors?

Mr. Brackett. Yes.

Mr. Karth. Send their engineers out and take a look and see what the subcontractors are doing insofar as quality control and production, et cetera.

Mr. Brackett. They depend on the particular subcontracts, but in general, yes, sir. The prime contractor is responsible for making sure everything that finally goes in works.

The actual quality control, of course, is done at the sub's plant. The prime contractor—at the subcontractor's plant—the prime contractor is responsible for working with NASA and with the subcontractor to make sure the right quality control procedures are present. He has to evaluate the technical worth of the output of the subcontractor. He plays a very important role.

Mr. KARTH. Thank you.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. On page 2, Mr. Brackett, of your statement, at the bottom, you discuss the Bendix contract for operation of five stations in Project Mercury tracking network.

Isn't it true that a number of other nationally known companies with proven experience submitted bids below that submitted by Bendix?

Mr. BRACKETT. I think you are correct, there were a few. I believe on the first negotiation we had eight bids. I can't recall exactly where—not bids, but proposals—where Bendix ranked so far as the estimated costs concerned with those.

There were several quite a bit higher estimated costs.

Mr. HECHLER. How do you defend superior technical competence, then, in the case of your decision to award this to Bendix?

Mr. BRACKETT. The decision was that Bendix would do the best job for NASA at probably the lower cost. Some of the companies that made proposals at a lower cost, there was no certainty they would produce for that cost.

This was to be a cost-plus-fixed-fee contract. NASA's estimate of what the cost would be, by our technical people, was in the range of the Bendix proposal.

Mr. HECHLER. What penalty, if any, is in the contract if the estimate of cost presented by Bendix is exceeded?

Mr. BRACKETT. There is no penalty. If they exceed the cost, this will be one of the factors taken into consideration as to whether they are entitled to an additional bonus fee.

Mr. HECHLER. Has there ever in the history of NASA been a case where you observed a contractor has been able to perform in such a way as to get a large windfall and was there any effort by NASA to renegotiate?

Mr. BRACKETT. I have known of none, sir, where their profit has been considered excessive.

Mr. HECHLER. You do not think such a situation would ever arise in the future?

Mr. BRACKETT. I would not say that would not happen.

Mr. HECHLER. Do you think you should take steps to prevent such a situation and protect the taxpayers?

Mr. BRACKETT. We try to do all we can to do that, sir.

Mr. HECHLER. You have no specific recommendation?

Mr. BRACKETT. On these cost-plus-fixed-fee contracts, the fee is fixed on the estimated cost at the time the contract is made.

The only way that a contractor could get a windfall, I believe, would be if he had a real serious underrun of costs that would increase the amount of fee proportionate to his actual cost.

Mr. HECHLER. I would like to shift, very quickly, to another question in the minute I have left. I take a different position than Mr. Fulton on the question of distribution of contracts. I believe very strongly there are occasions when available and trained labor supply, cheap land, good transportation, available facilities, will justify more distribution of contracts geographically at a lower cost, and I wonder if you take these facts into consideration also.

Mr. BRACKETT. We always take costs into consideration, whether it is an estimate or whether it is a fixed-price contract, as one of the elements in awarding the contract. Companies that do have a lower estimated cost, lower overhead, get a plus toward selection.

Mr. HECHLER. Are you concerned also about the strength of the national economy?

Mr. BRACKETT. Yes, sir.

Mr. HECHLER. And dispersion of very vital installations?

Mr. BRACKETT. I do not think we have quite the dispersion concern that, perhaps, the military do, but we are trying to distribute our contracts over a wide range.

The CHAIRMAN. Mrs. Weis?

Mrs. WEIS. No questions.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Mr. Brackett, of the 83 percent of the total contract dollars spent in the field of research and development, can you tell us how that is broken down, how much is done by NASA and how much by industry, how much by universities?

Mr. BRACKETT. During this period, I think I can, sir.

I think there was—you are talking about dollar values?

Mr. DADDARIO. Either dollar values or percentages, however you may have them.

Mr. BRACKETT. Fifty percent, I believe, was spent directly with commercial businesses.

Twenty-seven percent through other Government agencies.

The jet propulsion lab received 19 percent.

Four percent went to nonprofit organizations, including colleges.

Mr. DADDARIO. Is it the plan of NASA to maintain these percentages, or is there a hope that there will be a change? For example, will universities play a greater part in the future?

Mr. BRACKETT. They are continually playing a greater part.

Mr. DADDARIO. Does this mean that the percentage of research and development to be performed by universities will grow appreciably in the years to come?

Mr. WYATT. I do not know that we can say the percentage will increase because our budget is going up so rapidly. The sheer dollar volume to the universities will be increasing.

As measured against the doubled budget, I am not sure the percentage will go up.

The CHAIRMAN. Is your 10 by 10 program designed to get more of this?

Mr. BRACKETT. That is one facet.

Mr. DADDARIO. We should not be talking about it in the area of percentage. But it is your intention there will be an increased dollar volume to universities so that the universities will play a greater part in this program as the years go on?

Mr. WYATT. That is correct, sir.

Mr. DADDARIO. Mr. Brackett, you spoke off the record, when you were talking about small business concerns, and said that 20 of the largest contracts had been placed with small businesses; is that correct?

Mr. BRACKETT. Twenty of the hundred largest contracts that NASA placed.

Mr. DADDARIO. Twenty of the hundred largest contracts.

Mr. BRACKETT. Twenty went to small business concerns.

Mr. DADDARIO. Mr. Chairman, could we have those provided for the record, with breakdown by the contracts?

The CHAIRMAN. Yes. It will be supplied for the record.

Mr. WAGGONNER. If the gentleman will yield?

As part of that information, would they give us their definition of small business?

Mr. DADDARIO. Yes.

Mr. WAGGONNER. Their description of small business.

Mr. BRACKETT. It is the definition that is fixed by the Small Business Administration.

Mr. DADDARIO. I yield.

Mr. TEAGUE. Will this include whether it is a 100-percent set-aside for small business or what percentage?

Mr. BRACKETT. I do not know whether there were any set-asides in that.

(The following information was furnished for the record:)

ATTACHMENT 5

LIST OF 20 SMALL BUSINESS CONCERNS HAVING 20 OF THE LARGEST NASA CONTRACTS, JULY 1, 1961–DECEMBER 31, 1961

The following 20 firms were classified as small business concerns, at the time of contract awards, on the basis of the statements they are required to furnish to qualify as small business concerns:

[In thousands]

Firm	*Contract amount*
Management Services, Inc., Oak Ridge, Tenn	$1.547
Computer Application, Inc., New York, N.Y	1,322
Plasmadyne Corp., Santa Ana, Calif	970
Spaco Manufacturing Co., Huntsville, Ala	867
J. T. Schrimsher Construction Co., Huntsville, Ala	866
CompuDyne Corp., Hatboro, Pa	817
Redstone Machine & Tool Co., Huntsville, Ala	829
Gurtler-Hebert Co., New Orleans, La	695
Electro Optical Systems, Inc., Pasadena, Calif	589
Washington Technological Associates, Rockville, Md	501
Geophysics Corp., Boston, Mass	482
Noble Co., Oakland, Calif	466
E. C. Coston Co., Birmingham, Ala	427
S. & Q. Construction Co., San Francisco, Calif	375
Jackson & Moreland, Inc., Boston, Mass	317
Isomet Corp., Palisades Park, N.J	262
Kahoe Co., Bel Air, Md	261
Warland Inc., Chicago, Ill	243
Sciaky Bros., Inc., Chicago, Ill	218
Mount Vernon Research Co., Alexandria, Va	217

DEFINITION OF WHAT CONSTITUTES SMALL BUSINESS

The definitions of small business concerns are promulgated by the Small Business Administration (SBA).

Small business concern

(*a*) (*1*) *General definition.*—Except as provided in (2) and (3) below, a small business concern is a concern that is (i) independently owned and operated, is not dominant in the field of operation in which it is bidding on Government contracts, and, with its affiliates, employs not more than 500 employees, or (ii) is certified as a small business concern by the Small Business Administration. ("Concern" means any business entity organized for profit with a place of business located in the United States, its possessions, and Puerto Rico, including, but not limited to an individual, partnership, corporation, joint venture, association, or cooperative.)

(2) *Special industry definitions.*—Unless certified as a small business concern by the Small Business Administration, in addition to being independently owned and operated, and not dominant in the field of operation in which it is bidding on Government contracts, a small business concern in order to qualify as such must meet special criteria in the following industries:

(i) Construction industry: In the construction industry, the average annual receipts of the concern and its affiliates for the preceeding 3 fiscal years must not exceed $5 million; except that if the concern is located in Alaska, such receipts must not exceed $6,250,000. ("Annual receipts" means the annual receipts less returns and allowances of a concern and its affiliates.)

(ii) Aircraft equipment and parts industry: In the aircraft equipment and parts industry, the number of employees of the concern and its affiliates must not exceed 1,000 employees. This special definition for the aircraft equipment and parts industry applies only in the procurement of the following items:

Airframes and structural components.
Aircraft propellers and hubs.
Wheel and brake systems.
Jet engines.
Fuel tanks.
Aircraft hydraulic systems.
Aircraft vacuum systems.
Aircraft air conditioning.
Heating and pressurizing equipment.
Fire control systems.
Flight instruments.
Flight simulators (except small cockpit trainers).
Aircraft deicing systems.

(iii) Petroleum refining industry: In the petroleum refining industry, excepting procurement of lubricants and miscellaneous petroleum products, the concern and its affiliates must employ not more than 1,000 employees and not have more than 30,000 barrels per day crude oil capacity from owned or leased facilities. ("Crude oil capacity" means the maximum daily average crude throughput of a refinery in complete operation, with allowance for necessary shutdown time for routine maintenance, repairs, etc. It approximates the maximum daily average crude runs to stills that can be maintained for an extended period.)

(iv) Food, canning, and preserving industry: In the food, canning, and preserving industry, the concern and its affiliates must employ not more than 500 employees exclusive of "agricultural labor" as defined in 26 United States Code 3306(k).

(v) Air transportation industry: In the air transportation industry, the number of employees of the concern and its affiliates must not exceed 1,000 employees.

(vi) Trucking, warehousing, packing, and crating industry: In the trucking, warehousing, packing, and crating industry, the annual receipts of the concern and its affiliates must be $3 million or less; except that if the concern is located in Alaska, such receipts must be $3,750,000 or less. No such concern, however, will be denied small business status for the purpose of Government procurement solely because of its relationship with an interstate van line, if:

(A) The concern's annual receipts have not exceeded $3 million during its most recently completed fiscal year ($3,750,000 if located in Alaska), and

(B) No more than 50 percent of such annual receipts are directly attributable to the concern's relationship with an interstate van line.

(3) *Labor surplus area small business concerns.*—If a concern qualifies as a labor surplus area concern (see ASPR 1–801.1), the pertinent size standard (i.e., number of employees or annual receipts) shall be deemed to be increased by 25 percent.

(b) *Dominance in field of operations.*—A concern "is not dominant in its field of operations" when it does not exercise a controlling or major influence in a kind of business activity in which a number of business concerns are primarily engaged. In determining whether dominance exists, consideration is given to all appropriate factors including volume of business, number of employees, financial resources, competitive status or position, ownership or control of materials, processes, patents and license agreements, facilities, sales territory, and nature of business activity.

(c) *Affiliates.*—Business concerns are affiliates of each other when either directly or indirectly:

(1) One concern controls or has the power to control the other, or

(2) A third party controls or has the power to control both.

In determining whether concerns are independently owned and operated and whether or not an affiliation exists, consideration is given to all appropriate factors including common ownership, common management, and contractual relationships.

(d) *Number of employees.*—In connection with the determination of small business status, except as the Small Business Administration otherwise determines in a particular industry or part thereof, "number of employees" means the average employment of any concern including the employees of its domestic and foreign affiliates based on the number of persons employed on a full-time, part-time, temporary, or other basis during the pay period ending nearest the 15th day of the third month in each calendar quarter for the preceding four quarters. If a concern has not been in existence for four full calendar quarters, "number of employees" means the average employment of such concern and its affiliates during the period such concern has been in existence based on the number of persons employed during the pay period ending nearest the 15th day of each month.

(e) *Small business certificate.*—A small business certificate is a certificate issued by the Small Business Administration pursuant to the authority contained in sections 3 and 8(b)(6) of the Small Business Act certifying that the holder of the certificate is a small business concern for the purpose of Government procurement and in accordance with the terms of the certificate.

Mr. DADDARIO. One further question.

You have set up a program for the future which involves the choosing of contractors who can best accomplish the work.

Yet at the same time you hope for the opportunity to enlarge the field so that others may participate.

I wonder if these two positions are not at cross-purposes, one with the other, and if you are not having some difficulty in adjusting to both of these theories?

Mr. BRACKETT. This is one of the problems we are studying now, sir.

Mr. DADDARIO. You think, however, it can be done, on the one hand you can get better industry participation and on the other hand also overcome that probability which Mr. Karth has referred to, where you will tend to go toward the well advertised national concern and virtually keep the small businessman out because he has not had an opportunity to prove his capability to perform?

Mr. BRACKETT. Well, we are trying to bring in more small business companies all the time in the program.

Mr. DADDARIO. I am not complaining about it, but wonder if this is not a problem.

Mr. BRACKETT. No, I think we can, sir.

Mr. DADDARIO. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Bell.

Mr. BELL. No questions.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. Mr. Chairman, I would like to ask: A minute ago, Mr. Brackett spoke of—maybe Mr. Wyatt too—of first bracket subcontractors, and started to give the definition of what is a first tier. What is the definition of first tier? What is the money amount that defines a first tier subcontract?

Mr. BRACKETT. The first tier would be considered a contract immediately under the prime, let by the prime to a company immediately under it.

Mr. DAVIS. Then, the money amount does not determine it?

Mr. BRACKETT. No.

Mr. DAVIS. Not a criteria?

Mr. BRACKETT. No. That first subcontractor may let a second tier subcontract.

Mr. DAVIS. You said they must be approved by NASA.

Mr. BRACKETT. They are approved, sir. At times this is a function that is assigned to one of the military departments that are doing our inplant contract administration.

At other times this is reserved to our NASA people.

Mr. DAVIS. That approval would exist more in the form of a vehicle to power——

Mr. BRACKETT. Yes.

Mr. DAVIS. Rather than an active selection of a subcontractor.

Mr. BRACKETT. Yes.

Mr. DAVIS. Does that parallel the system used by DOD?

Mr. BRACKETT. I think we go a little stronger in taking a look at the subcontracts than perhaps they do.

Any subcontract of $5 million or more, first tier, before that subcontract can be approved there must be information given to this headquarters so that our technical people and ourselves can take a look at the terms before it is approved.

I do not believe the military do that.

Mr. DAVIS. Thank you. That is all.

The CHAIRMAN. Mr. Ryan?

Mr. RYAN. No questions.

The CHAIRMAN. Mr. Corman?

Mr. CORMAN. Mr. Wyatt, you do not give any weight to the state, or to the degree, of surplus labor in evaluating a proposal, do you?

Mr. WYATT. We certainly give weight to the availability of labor. In the large cases, generally, whether it is a labor surplus area is quite often overweighed by other factors. We consider it, but it may be completely overweighed by the technical competency factor.

Mr. CORMAN. Other things would have to be equal?

Mr. WYATT. Yes, sir.

Mr. BRACKETT. May I remark, our regulations provide for set-asides for surplus labor areas in those types of procurement where we can do it.

Mr. CORMAN. What percentage of set-aside have you had for that purpose?

Mr. BRACKETT. Not very much. We do not buy too much in the standard items.

Mr. CORMAN. It would have to be a standard item?

Mr. WYATT. Yes.

Mr. CORMAN. I would like to say, since the issue has come up, that my district did not sell one ton of coal to the Government last year, but I doubt that it was because of favoritism. I think it was inability to deliver.

The CHAIRMAN. Mr. Waggonner.

Mr. WAGGONNER. You spoke in your statement about a contract with Bendix which was an incentive type contract for superior performance.

Could you tell us what would constitute a superior performance?

Mr. BRACKETT. I believe there are six criteria set up: One is the time, if any, the station would be down; another would be its turnover of personnel—it costs money to replace people and train them; a third would be whether their costs were within the estimate or were able to reduce costs; another was improvement in performance, continually trying to make them work better.

So, you come up with new ideas for technical improvement. Another would be logistic support. They are charged with the duty of having spare parts and equipment so they are not out of repair. If they should fail because the equipment was not present—spare parts—this would be against them.

I cannot remember what the last one was.

Mr. WAGGONNER. Would you agree, in part, although I know this is not totally true, just the performance of those things alone would do nothing more than really constitute their deliverance or producing what they said they were going to do, and there would not be really anything superior?

Mr. BRACKETT. We have had experience with this network already, of course. If it did perform better than it has in the past—certain things they did—this would be taken into consideration.

Those six criteria, let's say, are not the only things that can be considered. Those are specific points that will be definitely considered.

Mr. WAGGONNER. That is all.

The CHAIRMAN. Mrs. Riley?

Mrs. RILEY. No questions. Thank you, sir.

The CHAIRMAN. The counsel of the committee has a question.

Mr. HAMMILL. Mr. Wyatt, the space program has required the construction of some expensive facilities by contractors——

Mr. WYATT. Yes, sir.

Mr. HAMMILL. Such as environment test chambers, et cetera. It is probably fair to conclude that the cost of these facilities inevitably finds its way back into Government contracts.

I am wondering if there is a national inventory of these expensive facilities and what efforts, if any, have been made to utilize them most effectively and thereby keep down duplication of construction of such expensive facilities and equipment?

Mr. WYATT. As to the first point, I believe there is such an inventory, particularly in areas such as environmental chambers.

I cannot speak firsthand, but I am sure there is.

We, of course, take into account in the evaluation of the contractor to be selected whether or not he has facilities or has arranged access to facilities, or whether he says that for him to do the job the Government will have to provide additional facilities.

This becomes one of the weighting factors in determining the cost of doing the work with that contractor.

In general, we have tried to avoid building up facilities at contractors' plants in situations where it would obviously not be available to other contractors in future contracts, and in these areas we have generally tried to place these kinds of a facility at Government-operated installations, either by NASA or DOD, or to make arrangements so that the facility could be used by other contractors.

We have gone so far as in the vehicle assembly areas for the Saturn C–1 and Saturn C–5 to actually activate the Michoud plant where the Government will own the plant and the contractors will work in the plant for the duration of the contract, but it is not their plant.

Here we felt we could pool two contractors—in this case the Chrysler Corp. on the S–1 stage and the Boeing Corp. on the S–1–B stage to a very great cost advantage to the Government.

We do take these things into account in the selection of the contract, selection of the place of performance of the contract, if there is a choice within the facilities.

Mr. Hammill. Thank you.

The Chairman. It is now 11:53. We have three more witnesses to hear today, and we certainly want to hear from them.

We have Major Petrone from Cape Canaveral, whom we want to hear, and Dr. McCall, from Huntsville.

Would it be better for you, Major Petrone and Dr. McCall, to come in tomorrow morning at 10 o'clock? Then you can go back to the cape and to Huntsville. We will see that our other witnesses are notified.

We will proceed, then, with Dr. McCall and Major Petrone and Mr. Cortright tomorrow morning.

Mr. Fulton. Mr. Chairman.

The Chairman. Mr. Fulton.

Mr. Fulton. The point I would like to make is this.

Many areas, industrial areas, in cities are very willing to take part in the space program. I come from the city of Pittsburgh and we do not have coal mines around our area but do have 1,800,000 people in the county and 3 million in our particular industrial area.

We in Pittsburgh have 2,200 people of doctoral level on research and development, constituting one of the largest research and development centers in the country, so that we are competent, but we have very few space contracts, I might add.

Secondly, we in Pittsburgh are putting one quarter of a billion dollars, $250 million in the next several years into a research and development center, and we wish NASA would consider it.

Further, I wanted to ask this one point on the installation at Sugar Grove, W. Va., the big dish that the Navy is now canceling.

Has NASA considered and has the National Science Foundation considered to what use that installation might be put, first because West Virginia is a depressed State, and secondly, we have spent, I understand, $47 million on the sites so far.

Are there installations that could be placed there at a saving to the Government and what investigation has been made to utilize this site?

Mr. Wyatt. Mr. Fulton, such an investigation is underway at the present time. We have not yet reached a point where we can give a definitive conclusion.

The Chairman. Before you do this, it would have to be declared surplus.

Mr. Wyatt. Yes. We are looking at it at this time.

Mr. FULTON. As we finish—NASA has an installation and it is going ahead on the buildings so that if it is going to be a duplication you should cease your program; and likewise, the National Science Foundation also has under construction a dish, and if that would be duplication, that likewise should be ceased.

So, that at this time we should look into that promptly.

Mr. WYATT. Yes, sir, we are so doing.

The CHAIRMAN. That is not the function of these people, it is the function of the National Science Foundation, and I think the Bureau of the Budget would take the overall interest.

The committee stands adjourned until 10 o'clock tomorrow morning.

(Whereupon, at 11:50 a.m., the committee recessed until the next day, being Wednesday, July 25, 1962, at 10 a.m.)

WAYS AND MEANS OF EFFECTING ECONOMY IN THE NATIONAL SPACE PROGRAM

WEDNESDAY, JULY 25, 1962

House of Representatives,
Committee on Science and Astronautics,
Washington, D.C.

The committee met at 10 a.m., Hon. George P. Miller (chairman) presiding.

The Chairman. The committee will be in order. This is the second day of hearings on ways of effecting economy in the national space program.

This morning we are privileged to hear Dr. J. C. McCall, Assistant to the Director of Marshall Space Flight Center, Huntsville, Ala. Dr. McCall was scheduled to appear yesterday, but time did not permit his taking the stand. Many thanks for staying over to be with us today.

You may proceed, Doctor.

Dr. McCall. Mr. Chairman, I have a prepared statement which I will read, with your permission.

The Chairman. All right, sir, you may proceed.

STATEMENT OF DR. J. C. McCALL, ASSISTANT TO THE DIRECTOR, GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.; ACCOMPANIED BY D. D. WYATT, DIRECTOR, OFFICE OF PROGRAMS, NASA

Dr. McCall. To discuss economies in the development of space vehicles it is necessary that we understand that there are two fundamental differences between fabrication of space vehicles and the production of commercial goods:

One is that space vehicles will never be produced at rates comparable to high production rates of commercial goods, and therefore normal mass production economics cannot be realized.

Second, that space vehicle fabrication must strive for the ultimate in quality and reliability. Economy is realized by producing a successful vehicle.

Our work at the Marshall Space Flight Center in the development of a space vehicle covers a very broad field including propulsion, engines, electronics, guidance, control, networks, data transmission and analysis, structure design, materials development, trajectory analysis, fabrication, assembly, large scale testing and finally launching of vehicles.

It is the proper control of every aspect of this field by a competent Government organization that produces economy in vehicle development and production.

I have been asked to comment on one small portion of this total field to indicate how we are striving for economy in this particular area; namely, fabrication of vehicles.

It must be kept in mind, however, that this is only one small part of our work and our expenditure of funds.

The Marshall Space Flight Center has conducted studies in the application of modular tooling as an element to provide economy and flexibility in space vehicle development.

In this concept the overall tool, which can be envisioned as a huge welding machine for the fabrication of a large size tank structure, is broken down into individual modules all of which are as flexible as possible. This has the following advantages:

It cuts tool fabrication leadtime, which in such a case could be substantial.

It provides economy in that the individual modules can be reused. It provides flexibility in that they can be adjusted to similar and other requirements in a speedy manner.

There are other areas where economy can be realized; for instance, in the forming of very large component parts for which conventional tooling equipment would be very expensive.

New methods, under development at present, are aimed at reduction of toolup time and tool costs.

An area where sizable savings are being realized already within industry is in the application of numerically controlled machine tools. Equipment of this nature is very expensive; however, savings can be realized by the vast increase of output of individual parts to be fabricated; for example, milled segments for vehicle containers.

This method permits very speedy fabrication, and nearly eliminates necessary inspection, and provides a high degree of uniformity.

In measuring the potential savings as result of the application of such techniques, it must be borne in mind that they apply to hardware items only, such as the structure of a vehicle system.

In the development of a space vehicle system the overall development costs arise primarily from scientific and engineering development effort, and economy which can be realized in the fabrication of hardware and tooling is relatively small within the total expense.

The following new fabrication techniques are being used or are under development and will contribute to reducing costs of fabrication of space vehicles:

1. Modular tooling concept, sometimes called soft tooling; welding operations on big containers normally require rigid, heavy, and precise fixtures for accurate alinement and clamping.

A new tooling concept has been developed to accomplish exact alinement and quality welds by use of flexible backup bars, local clamping devices, and seam tracking devices as tool modules which are adaptable to different vehicle diameters and gage sizes of material.

This concept reduces tool costs considerably and saves tooling-up time. One important tool module consists of a miniaturized weld head and a carriage track which is attached to the vehicle by vacuum cups.

The small tool module travels on the track to perform the welding operations, thus eliminating the need for large and costly tooling for accurately rotating the immense vehicle tank under a fixed welding rig.

2. High energy rate forming: Three methods are under development and being applied:

(*a*) Electric discharge forming: Electric energy, stored in capacitor banks, is discharged under water by exploding a bridge wire; shock waves are thus created in the water and form intricate parts which frequently cannot be manufactured by conventional methods without exorbitant expense.

(*b*) Magnetic forming: Electric energy from a capacitor bank is discharged through coils which create magnetic forces between the workpiece and coil. This is one of the most versatile of all forming methods and is presently being used for test component fabrication. It can be used in space for maintenance and repairing work by astronauts.

(*c*) Explosive forming: An explosive force is used to push the sheet metal into a die cavity. Major advantages include low-cost facilities, low cost energy source as compared with conventional press or stretch forming methods. This is especially apparent for forming of large size components.

3. Hydraulic bulge forming: This process eliminates the use of big hydraulic presses and expensive stretch forming equipment with inherent high tooling costs by applying hydraulic pressures directly to sheet or plate material to push the metal into a die cavity which is the contour of the desired part.

Important advantages include—

(*a*) Large-size components can be fabricated in one stroke.
(*b*) Low tooling costs.
(*c*) Uniform stress distribution in formed parts.
(*d*) Minimum permanent facilities.

4. Numerical control machining: Numerically controlled machining uses a prepunched tape to automatically control the movement of the cutting tool over the workpiece. Important advantages include—

(*a*) Machining plan is established by an expert.
(*b*) Minimized tooling.
(*c*) Prototypes can be easily manufactured.
(*d*) Precheck of tape program on digital and analog computers can be made.
(*e*) Human element for error nearly eliminated.
(*f*) High machine utilization possible.
(*g*) Excellent control on dimensions and tolerances.
(*h*) Very economical for low quantity production.
(*i*) The same part can be made later without extensive effort.

5. Welding (*a*) Automation of welding machine controls: By automatic control and programing of welding machine variables such as voltage, current, speed, tilt angle of weld head, feed wire rate, and so forth, substantial savings in tool costs can be accomplished.

This automation eliminates human errors in operation thus reducing costs of repairs of defect welds and scrap.

Automated welding machines can be utilized in many applications for different stations of vehicles, alloys, and configuration thus eliminating development of special equipment.

(*b*) Electron beam welding: Major advantages of this process are the extreme depth of penetration and the high weld efficiency obtainable. The first feature will eventually eliminate multipass welding for heavier gages while the high weld efficiency will result in very small heat affected zones which will reduce the weight of structures by several thousand pounds.

This, of course, increases the performance rate of propulsion systems.

In conclusion, let me assure you that we are making every effort to perform our tasks in the fabrication area as well as in all the other areas I mentioned earlier in the most economical manner possible without, however, sacrificing quality or reliability and without letting the schedule slip.

As we develop these techniques and discover techniques developed by others, we not only pass this information on to our contractors but also in some cases force the contractor to use methods which are well known to be the best.

We believe this is the proper function of the Government and can only be accomplished by maintaining a technically strong organization within the Federal Government.

The CHAIRMAN. How do you maintain quality control at Huntsville, Doctor?

Dr. McCALL. We have a division in our organization called the Quality Division and this Division has procedures which are in written form and which are distributed to the contractor and made a part of the contract at the time it is signed.

These people also follow up with teams located at the contractor's plant to be sure that the contractor follows these procedures and in many cases to do side-by-side inspection on critical items and critical tests with the contractor.

There are many of the large tests that cannot be started without our concurrence.

With these teams—I would say team effort of inspection and penetration into the contract operation—is our main tool for assuring quality.

The CHAIRMAN. As you introduce these new techniques and prove them out, I presume then you disregard those things that they have replaced?

Dr. McCALL. Yes. We go one step further. We try to document not only the technique that is being used now but also the technique which has been discarded, so there will not be a tendency later to regress into what was previously thought to be good procedures which some new person migth not know has been improved upon.

One of the things which we try to do is to maintain long-term continuity to be sure we are always improving and never regressing.

The CHAIRMAN. I think the emphasis should be placed on the word "regress."

This is important.

Mr. WYATT. If I may comment: One of the reasons that we asked Dr. McCall to highlight this particular area is that here is a place where not only is it beneficial to our space program in the conduct of the manufacturing of these new and unique articles, but it also represents a combination of in-house effort at the Marshall Center and contract effort which will have a marked influence on the whole industrial capacity of the Nation in nonspace as well as space areas.

The CHAIRMAN. I think this is one of the places where the Government through in-house effort can set the tone, strange as it may seem, for contractors, and I congratulate you.

Mr. Fulton.

Mr. FULTON. To me the greatest economy is the booster vehicle that operates efficiently and there is a successful launch and there is no substitute.

Mr. WYATT. Yes, sir.

Mr. FULTON. That is all.

The CHAIRMAN. Mr. Karth.

Mr. KARTH. No questions.

The CHAIRMAN. Mr. Van Pelt.

Mr. VAN PELT. No questions.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. How many people do you have in your Division carrying out this activity?

Dr. MCCALL. At Marshall Space Flight Center or the Quality Division?

Mr. RIEHLMAN. Quality Division.

Dr. MCCALL. I am not a part of that Division, but in the Quality Division we have about 500 people. It is in that range.

Mr. RIEHLMAN. Are they all located at Marshall Center?

Dr. MCCALL. No, sir.

We have a certain number located at the contractors' plants. Normally, our procedure at the contractor's plant is to have two kinds of people.

One are contract administration people, who are the only people that can actually tell the contractor what to do, and a team of technical people. Usually the Quality Division will have a certain number of its people located at the contractor's plant permanently, and who come back to Marshall periodically for retraining, updating, and liaison.

Mr. RIEHLMAN. This is a corps of people who are completely conversant with the contract let and follow it through.

Dr. MCCALL. Yes, sir.

Mr. RIEHLMAN. And know that the Government is getting exactly what it is contracting for.

Dr. MCCALL. Yes, sir. That is our philosophy of operation.

Mr. WYATT. The quality effort, I might say, is not wholly represented by these 500 or so people at Marshall Center. We do utilize the armed services, cognizant plant authority, the Air Force, Navy, or Army, as the case might be, in very large numbers. We have a cooperative program with the Department of Defense in this and are actually under negotiation on an enlargement of their effort on our behalf.

This is one of the most critical areas that we see in the whole program.

Mr. RIEHLMAN. I agree with you.

Dr. McCALL. We have our people located at the major contractor plants—Pratt & Whitney, Douglas, Lockheed, North American, and so forth.

Mr. RIEHLMAN. Thank you.

The CHAIRMAN. Mr. Corman?

Mr. CORMAN. No question.

The CHAIRMAN. Mr. Bell?

Mr. BELL. No questions.

The CHAIRMAN. Mr. Downing.

Mr. DOWNING. No questions, Mr. Chairman.

The CHAIRMAN. Then Mr. Wyatt, you are, through NASA, getting out to the contractors, and to other phases of NASA, the developments that are taking place, not only here but at other facilities of NASA?

Mr. WYATT. Yes, sir.

We feel this is an integral part of our charter, not only to produce the space mission, but see that the byproducts get out to industry at large.

The CHAIRMAN. Thank you very much, Dr. McCall.

Dr. McCALL. Thank you.

Mr. WYATT. Mr. Chairman, our next witness is Maj. Rocco Petrone, Chief, Heavy Space Vehicles Systems Office, Launch Operations Center, NASA, Cape Canaveral, Fla.

Major Petrone will talk to you in the areas of some of the work that we are doing to cut down the need for even heavier capital investments than are going to be required.

The CHAIRMAN. I welcome Major Petrone here. We have had the pleasure of knowing him.

Very happy to have you here, sir.

You may proceed.

Major PETRONE. Thank you, sir.

Mr. Chairman, I would like to read a prepared statement and then answer any questions the committee might have.

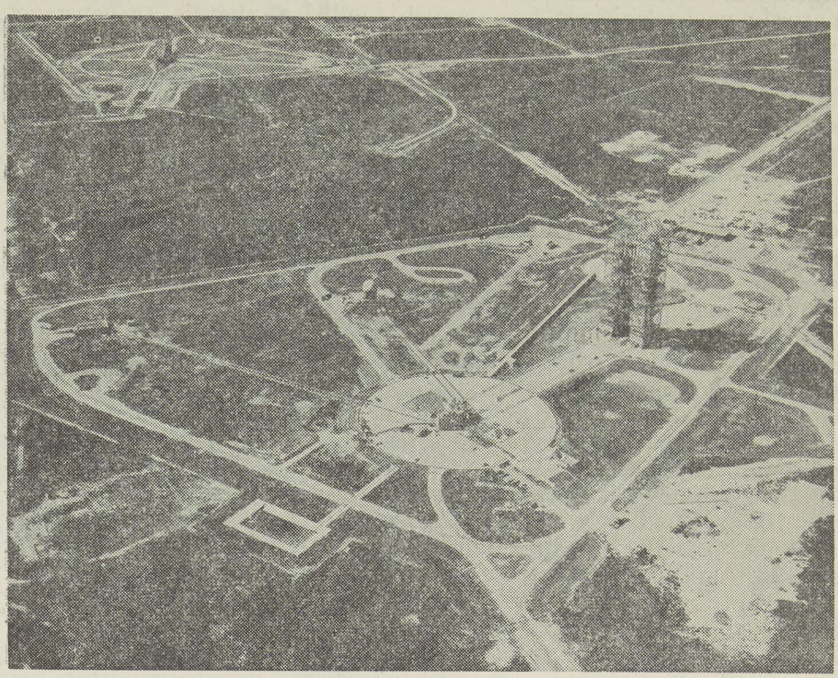
The CHAIRMAN. Proceed.

STATEMENT OF MAJ. ROCCO A. PETRONE, CHIEF, HEAVY SPACE VEHICLES SYSTEMS OFFICE, LAUNCH OPERATIONS CENTER, NASA, CAPE CANAVERAL, FLA.

Major PETRONE. In designing launch facilities for the Advanced Saturn C–5 vehicle, we are developing a new approach for launching space vehicles that will give this launch facility the flexibility of handling different configurations of this thrust class vehicle, provide the capability of greatly increasing the launch rates for this class vehicle without building new launch facilities, and reduce the number of skilled personnel required to launch at these rates.

Prior to outlining our Advanced Saturn C–5 launch facility, which is called complex 39, and further explaining the features I have enumerated above, I would like to briefly describe the launch facility now used for the present Saturn C–1, so that you may readily observe the key differences between our present method and the future method for launching and the potential capabilities that we are building into our new launch facilities.

(Slide No. 1.)



This is Saturn complex No. 34 at the cape from which we have already launched the first two Saturn C–1's of the R. & D. program. The large service structure (310-foot height, 2,800 tons) is shown in its position straddling the actual launch pedestal. The launch control center is 1,100 feet from this launch pedestal and must be constructed of heavy reinforced concrete to provide protection to that portion of the launch crew required to be in the launch control center at launch. The associated propellant (LOX, CH_2, and RP–1) and high pressure gas facilities are located at various distances away from the pad. Our method of preparing a vehicle for launch on this pad requires that the individual stages be transported to this pad, erected on the launch pedestal by using the crane on the service structure to lift each stage, and then commence on the pad the lengthy preparation required to assure that all the electrical circuits are connected and functioning properly, that the stages are in alinement, that there are no leaks in the propellant or high-pressure gas system, that the ground support equipment is all tied into the vehicle and functioning properly, and many other similar steps required to ready the space vehicle for launch. Presently we require 8 to 10 weeks to prepare a vehicle of the Saturn C–1 class for launch.

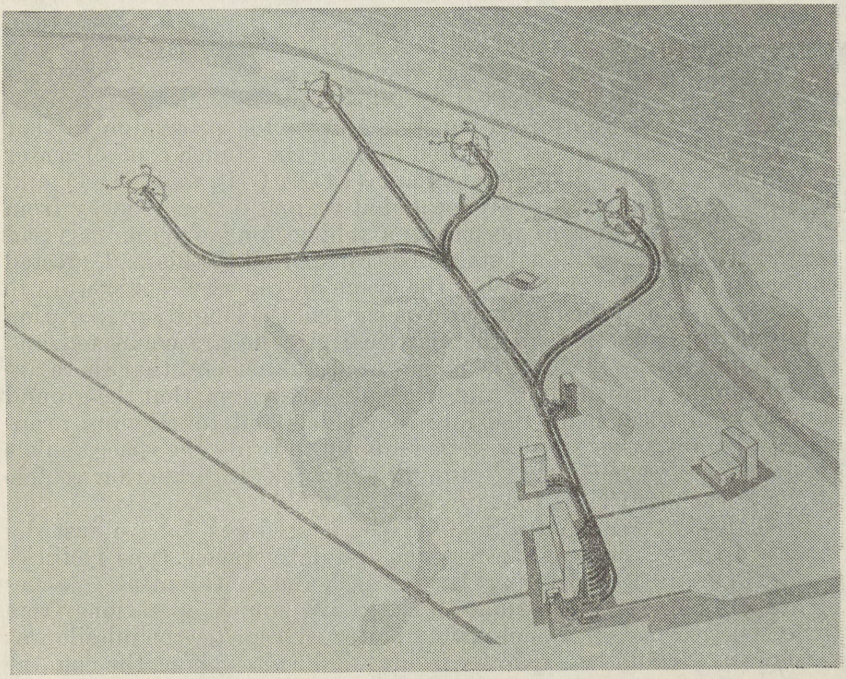
Basically the launch facility and the procedures I have just described are extensions of the research and development type facilities that have been built to support the research and development launches of our missile program to date. Extensive launch operations from these types of pads were not contemplated, since after the missile was developed, it could be sited at various missile sites about the country during the operational phase. NASA, however, was faced with an entirely new requirement in launch facilities—that is, to construct launch facilities from which the research and development phase of the program would be executed and which would also have the flexibility of supporting the operational launches of these vehicles at rates and frequencies which are really undetermined at the start of the program.

In early 1961, the Launch Operations Center started study programs to focus efforts on the feasibliity of designing launch facilities which could meet the requirements of both the research and development and operational phases of a vehicle program and which could handle varying launch rates, usually upward, without the requirement of building completely new facilities.

The Saturn C–1 launch facilities, complex 34, just described and complex 37, were too far committed to be changed by any results of the facility study mentioned above. Complex 34 had already been constructed and complex 37 was under actual design, and scheduled for immediate construction, since both of these complexes were required to support the C–1 program which was already underway.

However, the initial results of our study program on new launch facilities meshed very nicely timewise with the announcement of the manned lunar landing program in May 1961. We immediately took steps to apply these new concepts to the newly proposed Advanced Saturn program. After much study effort, some actual experimental testing, and preliminary design evaluation, we arrived at the following design for complex 39.

(Slide No. 2:)

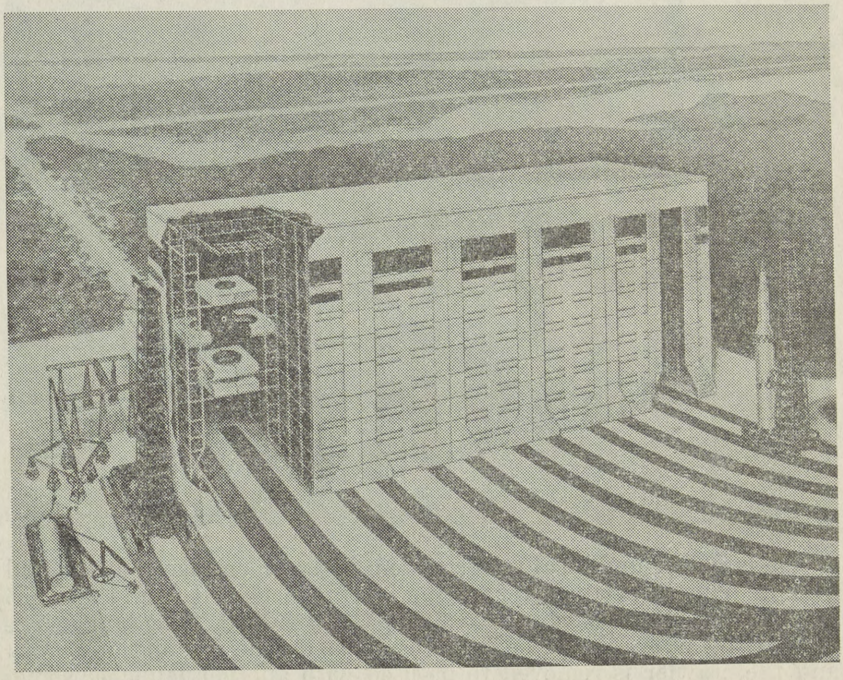


This artist concept gives an overall view of the layout of this launch facility. I have two additional slides giving closeup views of the vertical assembly building and the launcher transporter required to move the space vehicle from the VAB to one of the pads shown near the shoreline.

Our basic concept of launch preparation differs here from that now used in that the various stages and spacecraft are in this concept fully assembled and checked out on the launcher transporter in the vertical assembly building and only moved to the launch pad for the actual launch involving installation of explosive ordnance, propellant loading, that is, those operations that can really only be performed at the launch pad. By the departure from present methods, we have to spend about only a week or so on the pad instead of the 8 to 10 weeks we now plan for the C–1 program. The lengthy time required for assembly and checkout will be spent in this vertical assembly building operating in a more concentrated area in an industrial operational environment.

The distance from the vertical assembly building, which will also be the area from which we control the launch, to the launch pad is in the order of 2½ miles. We will use a digital data link between the VAB and the launcher on the pad with computers located both in the Launch Control Center and in this launcher system. The application of computer technology to the checkout and launch of these large space vehicles will, when fully developed, result in the ability to automate many of the checkout and launch functions which are now performed manually.

(Slide No. 3:)



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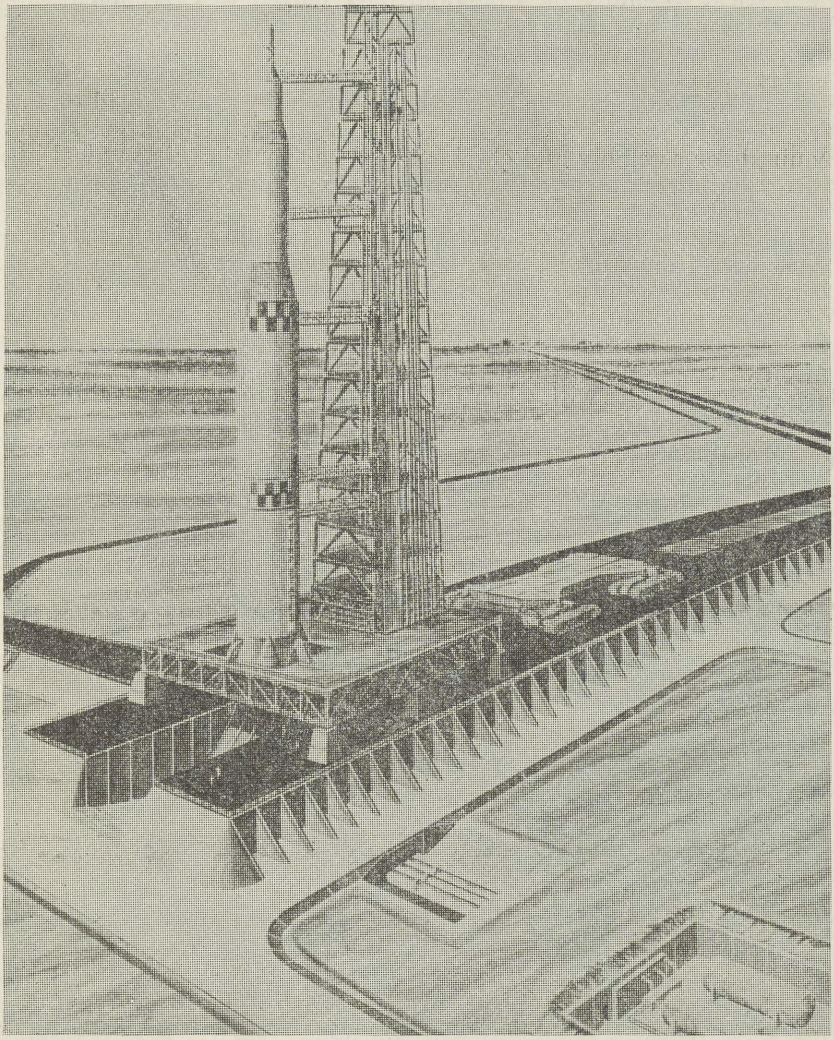
This is an artist concept of our vertical assembly building where the complete assembly and checkout takes place. To handle vehicles of the Saturn C–5 class, we need a hook height inside the VAB of 425 feet with a resulting 480 feet total height of building required. We estimate 8 weeks will be required in the VAB to completely assemble and checkout a Saturn C–5 prior to movement to the pad on the launcher-transporter.

(Slide No. 4:)



The launcher-umbilical tower system is shown emplaced at the pad over its flame deflector after having been transported from the VAB by the crawler-transporter over a prepared roadbed. The launcher is lowered by hydraulic jacks in transporter on the foundation shown and the crawler is removed to be used with another launcher somewhere else in the operation. The total weight of the launcher-umbilical tower with the empty liquid vehicle on it is estimated at 6 million pounds, with the crawler-transporter itself weighing 4.8 million pounds.

To enumerate the advantage of the mobile launch concept over the present fixed concept, requires that we select a launch rate for purposes of comparison. With 6 bays shown in the VAB, we can launch 36 vehicles a year. This same launch rate would require nine fixed complexes which would mean an investment of $900 million in launch facilities as compared to $450 million estimated for the mobile concept.

Manpower savings are an extremely important factor because of the scarcity of the skills of the type of manpower required. For a launch rate of 36 per year, we have estimated a requirement for 2,200 direct manpower to perform all the operations in the VAB and on the pad. For the same rate with the 9 fixed pads, we would need 3,700 direct manpower. At $12,000 a year salary per person, this would amount to annual reduction in requirement of 1,500 people and $18 million. If we calculate the difference at a lower launch rate of 24 per year, we would need 1,900 direct manpower in the VAB and on the pad versus 2,500 direct manpower for the fixed concept. This would amount to an annual reduction in requirements of 600 people and $7,200,000. These reductions in requirements in manpower are primarily due to the fact that we can now concentrate the lengthy launch preparation efforts and, therefore, make better use of our people.

Another feature that offers potential savings is the flexibility of handling different vehicle configurations. If we have to modify a launch pad today to introduce new ground support equipment for a different stage configuration or entirely new payloads, we have to take the entire facility out of action and deny the use of that pad during the period of modification. With the mobile concept, we can modify one launcher-transporter for the new ground support equipment and still continue to use the pad for launches.

We are presently sizing this facility so that at a later time we can introduce solid first stages for the C–5 class vehicle so that if solids are introduced in our space program in this class vehicle, we will be able to launch from these pads using these launcher-transporters.

There are other advantages, such as the improvement of working conditions, improvement of environmental conditions that this vehicle is exposed to for a prolonged period of time which add to the attractiveness of the mobile launch concept. However, these are greatly overshadowed by the inherent flexibility of handling different vehicle configurations, the ability to greatly increase the launch rate from the same pad areas, and the potential reductions in skilled manpower requirements for high launch rates.

To summarize, we are of the opinion that the steps now being taken to provide this mobile launcher facility for the advanced Saturn program will greatly enhance our launch operations for the space flight program now proposed and provide the capability to exploit the many advances and uses of space, which, although now only in its infancy, will inevitably result from the large investments now being made to assure the future of our country in space.

The CHAIRMAN. Thank you very much.

Mr. Teague, you are studying this problem.

Any questions?

Mr. TEAGUE. Have we ever lost a missile on the pad during checkout, Major?

Major PETRONE. I have not had any personal experience with any during checkout.

Mr. TEAGUE. What is the possibility of losing one inside of that assembly building?

Major PETRONE. The chances are remote. You do not introduce any explosive hazards.

It is remote from that standpoint, sir.

Mr. TEAGUE. Our subcommittee went into this to a great extent with Dr. Debus and Major Petrone at Cape Canaveral and the subcommittee came to the conclusion we have to go to this type of operation in using the rendezvous technique. I don't think I have any further questions.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Glad to have you here, Major.

I think you are a good addition to the program.

How do you arrive at the six bays in the building?

Would you explain that? Why you need a certain number of pads?

Major PETRONE. We had sized the pads——

Mr. FULTON. Could we have the slide again?

Major PETRONE. Slide No. 2, please.

We had sized the four bays—rather, the four pads—to support the rendezvous operation which would require a vehicle on the pad and a backup.

This was the Earth orbital rendezvous, sir.

Mr. FULTON. Would this complex 39 be available if we went to the Nova, could we launch the Nova rocket from this complex?

Major PETRONE. The specifications of the Nova, in both thrust and dimensions, is not defined, and the question is really not answerable. In terms of compatibility of introducing it, I would say yes, contigent upon thrust level and size.

However, since it appears that the Nova will be not in a sense backup but a next step forward, it will probably have a larger thrust class than 15 to 20 million pounds and therefore not be able to be launched from these specific pads.

Mr. FULTON. You will notice that if you look from the pad furthest away from the shoreline to the pads that are on the shoreline, you have an overflight of three pads.

Does that affect the safety?

Major PETRONE. Sir, this has been analyzed in great detail, the pros and cons, and we have accepted the risk of an overflight from the rearward pad with the understanding that that will primarily be our backup pad.

In any launch program you, unfortunately, have to be prepared for an explosion or disaster on the pad.

That is why we would use this pad primarily as our backup pad.

Mr. FULTON. My final question is, why did you choose the creeper crawler form of transportation instead of the rail and/or the barge form of transportation from the vertical assembly building to the launch pads?

Major PETRONE. I would say our primary reasons were technical, in that the crawler system we have adopted actually will be an inherent design already available.

These large crawlers are today used in stripmining. We studied one in particular at some length. It is actually of a larger size than the one we have here and has many inherent technical features, such as low acceleration rate, minimum sway of the vehicle while moving, and, technically, it was extremely attractive.

Mr. FULTON. Is it lower in cost?

Major PETRONE. On the cost factor, our roadbed per mile for the crawler with the weights we are carrying is more economical than the railbed. Barge would have the cheapest per mile cost. However, in experimental testing we encountered certain difficulties in propelling and stabilizing the barge.

The CHAIRMAN. What is the total weight now of a vehicle? I think you said 6 million pounds.

Major PETRONE. Six million pounds, sir, would be the payload—the launcher system—umbilical tower and vehicle. The crawler transporter is 4.8 million, giving us a total of just under 11 million pounds that must move on this roadbed.

The CHAIRMAN. 5,000 tons.

Major PETRONE. Yes, sir.

Our ground pressure is something in the neighborhood of 50 pounds per square inch.

Mr. TEAGUE. Is the time scheduled on this classified?

Major PETRONE. Time schedule in terms of readiness date, sir?

Mr. TEAGUE. Right.

Major PETRONE. No, sir. We have a readiness date for this facility of approximately April 1965, when we want to be able to launch our first C–5 vehicle.

The CHAIRMAN. Major, this vehicle is 380 feet high, I believe you said.

Major PETRONE. 350.

The CHAIRMAN. You sometimes get pretty heavy winds in this part of the country, don't you?

Major PETRONE. Yes, sir.

The CHAIRMAN. When this is on the crawler, have you designed against wind?

Major PETRONE. Yes. We have designed for a 65-knot gust, which is the level of wind that could come at random. For higher than that, which would be hurricane conditions, rather than designing the transporter and the vehicle to take hurricane loads, we would move it back to the building for hurricane protection.

The CHAIRMAN. Mr. Van Pelt.

Mr. VAN PELT. No questions.

The CHAIRMAN. Mr. Karth?

Mr. KARTH. Major, you build the vehicle right on the crawler, don't you?

Major PETRONE. I would say we assemble it, sir.

Mr. KARTH. You would not assemble it on a barge, would you?

Major PETRONE. The barge system we investigated, sir, really transported the same portion above the water line. Water was only the means of transport. The barge I referred to—and I did not explain in detail because Mr. Fulton was familiar with it—the barge, the crawler, and the rail were only means of transporting the launch umbilical tower system shown in my slide.

So the barge there is not to be confused with the barge used to transport the stage from the factory or test site to the cape.

Mr. KARTH. That is all.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. Major, what would be the length of time for moving one of these missiles from the assembly room to the farthest pad?

Major PETRONE. We can move 1 mile per hour. So it would be about 2½ hours, sir.

Mr. RIEHLMAN. The only thing I want to say, Mr. Chairman, is that I concur with the chairman of the subcommittee that while we were down at Cape Canaveral certainly Major Petrone was most helpful and constructive in his presentation to the committee, I commend him for it, and also for his presentation here today.

Major PETRONE. Thank you, sir.

The CHAIRMAN. Very happy to know that you recognize Major Petrone.

Mr. Hechler.

Mr. HECHLER. No questions, Mr. Chairman.

The CHAIRMAN. Mr. Mosher.

Mr. MOSHER. No questions.

The CHAIRMAN. Mr. Daddario?

Mr. DADDARIO. Mr. Chairman, I have had the opportunity to hear Major Petrone make a presentation on this subject before, as a member of Chairman Teague's subcommittee, and all I want to say is that I am pleased to have him here and to have the full committee see the grasp he has of this subject, and, I think too, probably as important, the dedication he shows to the tasks assigned to him.

The CHAIRMAN. I agree. Mr. Bell.

Mr. BELL. Major Petrone, on one of the advance stages of Saturn, I don't know which, I don't think it has been determined, they are talking about a nuclear vehicle.

Major PETRONE. Yes, sir.

Mr. BELL. Would there be a requirement for considerable change in your setup to make this available to the launch?

Major PETRONE. Building and transport will be the same. We have to add a specific nuclear assembly vehicle to install the reactor into the engine, so it is a specialized facility, as an adjunct to the building.

However, the stage then will be brought into this building, erected on the basic C–5 vehicle, transported to the pad with the transporter and launched from the same pad, sir.

Mr. BELL. That would be considerably more costly, would it not?

Major PETRONE. You mean the additional building we must add?

Mr. BELL. Yes.

Major PETRONE. The requirements for the nuclear assembly building are really in their inception of design. Our basic engine is under test in Nevada and we have work underway with the Atomic Energy Commission and the engine designer, so we do not have a cost estimate.

It is primarily a means of vertically handling what we call rift, reactor in flight. The test stage is placed in a vertical position to insert the reactor into the nuclear engine and make tests before we move the stage into the vertical assembly building.

Mr. BELL. Thank you. That is all, Mr. Chairman.

The CHAIRMAN. Mr. Morris.

Mr. MORRIS. Mr. Chairman, I have no comment except to say that Major Petrone has done his usual fine job in explaining this project and he did a very good job when the subcommittee was at Cape Canaveral.

The CHAIRMAN. Mr. Randall.

Mr. RANDALL. I also want to compliment the major.

Major, we have had questions about assignments. You are with the Army or Air Force?

Major PETRONE. I am Army, sir.

Mr. RANDALL. How long have you been with NASA?

Major PETRONE. Since July of 1960, sir.

Mr. RANDALL. Not having the pleasure to serve on the Manned Space Flight Subcommittee, when was this concept of this mobile assembly first commenced?

Major PETRONE. Early 1961, we started active efforts.

Mr. RANDALL. We became committed to it when? shortly after that?

Major PETRONE. We became committed with the announcement. We studied it in application to the manned lunar landing program for the C–5.

We wanted to assure ourselves that technically, although this does present a challenge, we could design this in the time allowed prior to the launch of the first C–5.

Mr. RANDALL. It will not be operational, however, until 1965?

Major PETRONE. Which would be in consonance with the schedule for launching a first Saturn C–5 program.

Mr. MORRIS. That does not mean it could not be operational prior to that time if they gave you the proper tools to work with.

Major PETRONE. No. We feel we can stay in consonance with the development of those stages.

Mr. RANDALL. On the barge business, I am a little confused. I assume a barge contemplates the use of water.

Major PETRONE. Yes, sir.

Mr. RANDALL. Did I understand you correctly that you have never had but two methods, rail or crawler, for the assembly vehicle for the mobile concept, is that correct?

Major PETRONE. No, sir. In our program we looked at three methods of moving this launcher umbilical 350 feet high from the vertical assembly building to the pad.

One very appealing feature in our area, because of the water table, is use of the canal. So the question arose, Why not use a barge which can carry very large weights to move this 6-million pound, 350-foot-high payload to the pad? We actually had under study with naval architects and ran experimental testing at David Taylor Model Basin—had the Navy do the tests for us—and there were certain indications of propulsion problems in terms of moving steadily in winds, plus the fact that wind caused this large sail, you might say, to sway.

Mr. RANDALL. That is what I was getting at, you have a barge on water, and then I thought about the problem of getting the vehicle transferred.

How do you propose to do that?

You are on an unstable case.

Major PETRONE. We have gone into the study of all of these in some depth. We floated into a, you might say, a pit, an area where we had a lock, then closed the lock and dewatered and lowered this onto the foundation.

Mr. RANDALL. One other question about the wind.

How are you going to brace this?

How can you be sure it will withstand the 65-knot wind?

Major PETRONE. We have tested this in close cooperation with the vehicle designers and under 65-knot winds the loads we expect to encounter will cause a vehicle sway of something like 30 inches—the vehicle itself at the——

Mr. RANDALL. At the top?

Major PETRONE. Yes, sir; with the loads known and the anchor we have we will be able to withstand those loads.

Mr. RANDALL. Thank you, Major.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. Major, I read recently of a factory where it was necessary to move articles weighing several tons and they discovered that by pumping compressed air in the article, or through it, one man could easily push it around. It so happened we had some hearings several weeks ago about ships which travel on a cushion of air that weigh a hundred tons or more.

Did you investigate the possibility of moving these objects on a cushion of air?

Major PETRONE. Yes, but not in the depth of the three methods that have been discussed—barge, rail, and crawler.

There are many different names for this process.

We felt it was not sufficiently developed to handle the weights with which we were concerned. We felt there would have to be more of a research and development program involved and did not want to tax our already challenged engineering load with this additional requirement, whereas the three systems we were studying in depth were in being, in effect.

We did look into the air layer principle, sir.

Mr. DAVIS. That is all.

The CHAIRMAN. Mr. Corman.

Mr. CORMAN. No questions.

The CHAIRMAN. Mr. Downing?

Mr. DOWNING. Major, what was the purpose of the canal which seemed to go around the periphery of that complex?

Major PETRONE. Put the slide back on.

We have to deliver our stages to the vertical assembly building by barge and that will take them from the Mississippi and deliver them. The remainder of the water happens to be the natural configuration. That one canal is for the delivery of the large stages in an horizontal position to the vertical assembly building.

Mr. DOWNING. You end up coming back to the barge or water transport now being the most feasible.

Thank you.

The CHAIRMAN. What are the other buildings in the picture? What is the one off to the right?

Major PETRONE. Sir, what we have shown here, in this artist's concept, are possible additions, one would be the nuclear vehicle assembly building that I referred to in answer to Mr. Bell's question.

The one further down the road, if I can use the term, on a roadbed, is an arming tower, which we would position there for installation of certain explosive items on the way to the pad.

So this artist concept gives a blow up of additional facilities, some of which, such as a nuclear building, we are not introducing initially.

The CHAIRMAN. Mr. Teague.

Mr. TEAGUE. Major, as I understand the whole space program, rendezvous will be a very important part of it in the future.

Major PETRONE. Yes.

Mr. TEAGUE. Rendezvous is one of the reasons for this type of operation.

Major PETRONE. Yes.

Mr. TEAGUE. I know we will hear from Dr. Kavanau, but what coordination is there between NASA and the military as far as the use of an operation like this?

What about DOD?

Major PETRONE. Sir, I cannot address myself to all of that question.

In terms of relations with DOD, in our initial studies last summer, in the summer of 1961, we worked very closely with General Davis' staff, Air Force Missile Test Center, and with NASA, carried this up as a joint project, joint briefings of both Dr. Seamans and Mr. Ruble. There has been that type of coordination.

As far as actual utilization, I cannot address myself to that.

Mr. WYATT. If I may amplify, Mr. Teague, as I believe many of the members of the committee know, there has been an office of the Air Force established physically in the same building with Brainard Holmes' general offices headed by Major General Ritland. General Ritland represents General Schriever as Deputy Commander for Manned Flight in the Air Force and serves as both technical liaison to us and from us to make sure that the Air Force is aware of all work we are doing and that they can see every aspect of it and utilize the work to the extent they can in their own programs.

Mr. TEAGUE. Would we ever plan on a big rendezvous program without a launching facility such as this?

Would you ever plan rendezvous with pads like we have now?

Major PETRONE. The Gemini program is using smaller class boosters such as the Titan II and Atlas Agena, and will perform our experimental work in earth orbit rendezvous.

I would say as you get to the larger class vehicles it would be a pad or facility of this nature that would be used. Larger class being a thrust of a million and a half and above.

Mr. TEAGUE. Thank you.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. Following up what Subcommittee Chairman Mr. Teague questioned you on: Wednesday before the Committee on Government Operations, we were into this very same field, and we were given assurance by Dr. von Braun there would be no duplication of activity, when the Air Force decided this was a project that they were vitally interested in and would use.

The CHAIRMAN. I could see that the Air Force may want from their point of view additional facilities, maybe one or two, throughout the United States.

Mr. RIEHLMAN. Not a complete duplication.

The CHAIRMAN. Not a duplication, no, but where they could launch a vehicle, because their mission is entirely different than this.

Mr. RIEHLMAN. That is true.

The CHAIRMAN. You could not afford to have all your eggs in one basket.

Mr. MORRIS. Is the chairman suggesting we need one on the west coast?

The CHAIRMAN. As a matter of fact, I thought White Sands might be a good place. [Laughter.]

Mr. RIEHLMAN. More in the field of duplication of research, and in that field of activity, is what Dr. von Braun was talking about.

The CHAIRMAN. Yes.

Mr. RIEHLMAN. I would believe, if the Air Force found this was a project they were vitally interested in, they would probably have to have another facility at a later date.

The CHAIRMAN. Operationally it would be a great deal different. I see no reason why there should be duplication of this.

Mr. Fulton.

Mr. FULTON. Had you considered a sea launch of this size on a flotation principle?

Major PETRONE. Yes, we did, sir.

We looked into the Navy's project Hydra, and for this size vehicle, and the stability requirements, we felt that there was not sufficient evidence that we could handle the mobile sea launch for this class vehicle.

I might say there are additional studies still going on and in the future it might require offshore facilities or things of that nature, that are in study phase only.

We did look at the work that had been accomplished and decided it was not the way to go for our project.

Mr. FULTON. With a project of this size, of course, you have to have an industrial complex as a backup.

Would you comment on that shortly?

Major PETRONE. We have planned additional facilities at the range on our newly acquired property in Meritt Island, as we refer to, as the industrial area.

I do not have with me this morning any slides. But this would involve engineering laboratories, engineering administration, and the general support required to back up this operation.

However, in this mobile concept many items formerly in the industrial area will be concentrated in the vertical assembly building—machine shop support, electronic labs—because now we have in one place the requirement to support the operation and those items will be moved into the vertical assembly building.

Mr. FULTON. Could I ask you who pays you?

Are you on the military rolls now? When your are on leave to NASA you are on temporary duty?

Major PETRONE. I am detailed to NASA at the request of NASA from my service in the Army.

I am still on active duty.

Mr. FULTON. On temporary duty with NASA?

Major PETRONE. I am on a permanent detail to NASA.

Mr. FULTON. Who pays you?

Major PETRONE. I understand there are transfers of funds.

Mr. WYATT. He is actually paid by the Army, if I recall, but we reimburse the Army.

The CHAIRMAN. That is the same way we have our people here.

Mr. FULTON. You are really on duty in the Army?

Major PETRONE. Yes, sir.

Mr. FULTON. At the present time, and on permanent assignment to NASA?

Major PETRONE. Yes, sir.

Mr. FULTON. With no fixed termination date?

Major PETRONE. No, sir.

Mr. FULTON. Who determines how long you stay there?

Major PETRONE. I imagine it has to be a mutual agreement, sir, between the Army and NASA.

Mr. FULTON. Is this working out satisfactorily to NASA?

Mr. WYATT. Yes, sir, very satisfactorily.

The CHAIRMAN. What is your branch of service?

Major PETRONE. Ordnance Corps. I had been associated with this program previously with the same team on the development of the initial Redstone is the reason I am back into it.

Mr. FULTON. We have had quite a question on this.

You are my prime example that it works out well.

Mr. WYATT. We have no complaint.

Mr. KARTH. Mr. Chairman, if I could ask a question.

The CHAIRMAN. Yes.

Mr. KARTH. The polar orbit does not lend itself to the rendezvous technique, does it?

Could you rendezvous in polar orbit?

Major PETRONE. I believe we can. From this facility in Florida, to make a polar flight you would have overflight of nations that we do not contemplate overflying, but——

Mr. KARTH. I was just trying to ascertain if you could.

Mr. WYATT. Technically you could make the rendezvous in polar orbit. It is a question of placement of launch facilities to get into that orbit.

Mr. KARTH. It is not necessary that it go from west to east in the rendezvous technique?

Mr. WYATT. No, sir. There is nothing inherent in launching from west to east.

Of course, we prefer to launch to the east to gain advantage of the Earth's rotation.

In our program, as we presently conceive it, for the work we will be doing in rendezvous the near equatorial kind of orbit or low lattitude orbit will suffice.

The military may require a polar orbit for their operation. In our program at the present time, and down the road, we can get by with the low latitude orbits.

Mr. KARTH. To achieve the same objective you would have to have a greater thrust?

Mr. WYATT. Yes; you do not have the benefit of the Earth's rotation.

Expressed in terms of payload there is a marked reduction in payload with a given thrust for a polar launch. Therefore, a corresponding increase in thrust is required.

Mr. BELL. For the polar orbit your launching operations could take place at Vandenberg.

Mr. WYATT. Yes, in this country Vandenberg is the site that gives the direct south without overflight.

Vandenberg or Point Arguello.

The CHAIRMAN. I believe you would go a long way when you launch south from there before you have any overflight.

Mr. WYATT. Very long way, yes, sir.

Mr. FULTON. If this is a permanent assignment for Major Petrone, could I ask NASA what his pay is in respect to others in like positions in NASA, or civilians, because if it is put on the basis that this man is here permanently and becomes a permanent employee of NASA, I think it is unjust to him to keep him at a major's pay, because, certainly, at his level, the civilians are getting much more than that. If it is temporary it is a different thing.

Mr. WYATT. I think technically it is temporary. The Army has not rescinded their right to recall him.

Perhaps the major would have to speak to this, but each of the people that are assigned to us, within their own personal outlook, have to at some point make a decision whether they would prefer to actually resign or retire from the Army and move over to the civilian payroll or remain in military status.

Mr. TEAGUE. This includes astronauts.

Mr. WYATT. Yes, sir.

Mr. FULTON. When would that time come from NASA, that you say they become permanent employees?

Mr. WYATT. We have a number of military people with qualifications of the sort of Major Petrone that we are very happy to have with us.

I do not recall an instance directly in which any of them had resigned from the service and come over to full civilian status, but we would be very happy to have any number of these individuals do so.

Mr. FULTON. Would he get hazardous duty pay?

Major PETRONE. Probably only for appearing before the committee, sir. [Laughter.]

The CHAIRMAN. Thank you.

Mr. KARTH. It appears the only way the major can get an increase in pay is to resign from the Army and go to NASA.

I think you should consider it.

The CHAIRMAN. I think maybe that is a personal matter with the major.

I can understand how after many years of service—how much service have you?

Major PETRONE. I am in the 17th year now, sir.

The CHAIRMAN. I think he would be foolish to sacrifice 20 years at this point, but after that 20 years I think we ought to twist his arm.

Major PETRONE. I am very proud to be working for the Government in this position, sir.

I might add it has many of the compensations that money cannot get.

The CHAIRMAN. That is the spirit that I think has made this program a success.

Mr. BELL. Mr. Wyatt, getting back to polar orbit, it is my understanding that NASA has no manned space flight plan for a polar orbit.

Mr. WYATT. That is correct, sir.

Mr. BELL. Is that because of the way the Earth rotates?

Mr. WYATT. In our program, for the civilian application of rendezvous, there is no impelling reason we can see why man must fly in a polar orbit.

I am excluding any military consideration. But in the nonmilitary aspects, in terms of our lunar exploration program, we choose to get down in on a near equatorial orbit to get into the plane of the Moon, so that we desire to be in a low inclination orbit rather than polar.

Mr. BELL. If they found at the equatorial area the Van Allen belt became a serious problem would they not consider polar orbit?

Mr. WYATT. Even in the polar orbit, when you get away from the poles and nearer the equator, you are in the same belt. The advantage would only be in the period where you were near the poles. At this time I don't think we could assess that as a major factor.

Actually the orbital flights we are speaking of and have contemplated are well below the Van Allen radiation belt.

In the future we may have to cut through that belt.

The CHAIRMAN. To go to the Moon?

Mr. WYATT. Yes.

The CHAIRMAN. You can go north and south, if necessary?

Mr. WYATT. Only by using tremendous energy, sir. I think it would require boosters far beyond any that we are talking of if we tried to go out on a polar trajectory and make the right angle turn to go to the Moon.

The CHAIRMAN. If you rendezvous this could be done?

Mr. WYATT. You are still moving in this direction and the Moon is out there [indicating]. This means at an 18,000-mile velocity you have to turn the corner, kill all the motion in one direction, and acquire it in another.

This is prohibitively high in terms of energy.

The CHAIRMAN. Thank you, Major Petrone, and Mr. Wyatt. If there are no other questions——

Mr. FULTON. Has the decision been made to launch nuclear vehicles from Canaveral?

I did not think it had.

Mr. WYATT. There has not been a final decision. We are developing the nuclear stage known as Project Rift. We have at the present time, in conjunction with the AEC and with contractors, an intensive study of all of the hazards involved in the complete operation, from the movement of the reactor from where it is built to the test site, from the erection—all the problems incident there—the problems during the launch and during any fallout potential from it. We do not have a final conclusion. It is receiving intense study.

The CHAIRMAN. Thank you very much.

It is our privilege now to hear from Dr. Lawrence Kavanau, Special Assistant, Space, to the Director of Research and Engineering for the Department of Defense.

STATEMENT OF DR. LAWRENCE KAVANAU, SPECIAL ASSISTANT (SPACE) TO DIRECTOR OF RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE; ACCOMPANIED BY COL. WILLIAM A. CURTIN, JR., U.S ARMY

Dr. Kavanau. Mr. Chairman, I have a prepared statement I would like to give to you.

I would like to also mention that Colonel Curtin is here with me today.

The Chairman. Do you want Colonel Curtin at the table?

Dr. Kavanau. It doesn't matter.

The Chairman. It is up to you.

Dr. Kavanau. Mr. Chairman and members of the committee, I am honored to be afforded this opportunity to discuss with you the problem of how to save money in the space program.

There is, of course, no magic formula or easy solution. A lot of understanding is required—understanding of goals and purposes of our programs as well as understanding of the complexity of the technical, organizational, and manpower problems. A lot of hard work is needed. A lot of patience is needed.

There is a general tendency on the part of many to treat space and space programs as something entirely new, strange, and different and to look for unique, exotic approaches for solving the many problems associated with space programs. The exciting arena of space is new, just as nuclear technology was unfamiliar in the World War II period.

On the other hand, space programs are remarkably similar to many of our modern defense research and development problems.

There are similar problems of management, complexity, cost, reliability, and need for competent manpower.

Because this is so, I would like first to talk a little about broad research and development problems in the Department of Defense and and then to discuss how solutions to these apply to the particular space problems we face.

Most of my comments will be directed toward improvement of cost effectiveness in the short term rather than the long term. That is, the improvement of the conduct of our present programs rather than the initiation of new programs which are intended to save money in the rather indefinite future. In the latter category, I place the development of recoverable boosters, and other long-range research which may lower the costs of future operations.

Research and development, on the vast scale that we know it today, is extremely new. As you gentlemen know well, it is a very recently adopted way of life.

During the World War II era, development costs for a new airplane were in the order of only a few hundred thousand dollars. Aircraft were procured for less than $100,000. Now, development costs reach the staggering amount of hundreds of millions of dollars for modern airplanes like the RS–70 or missiles like the Atlas and the Titan.

Space-related research and development has grown from a few millions of dollars spent prior to 1957 to several billion dollars per year in a very short interval of time.

Federal space program obligations in fiscal year 1963 will exceed $5 billion. Total Federal expenditures, for fiscal year 1963, for research and development, will exceed $12 billion. Total Federal expenditures, as late as fiscal year 1958 were less than $5 billion. So, in just a few short years, our space research and development has reached a level which exceeds the total Federal research and development level of the period before sputnik.

Now, research and development is generally characterized by a very high ratio of engineers and scientists to nonprofessional personnel. In the space effort this is even more true than in the general case.

The requirement for engineers and scientists in this exploding technology has risen faster than the available supply of experienced, competent professionals. This is partially due to the advanced technology in use and partially due to the rapidly expanding rate of effort. The net result is that the quality of vitally needed management has tended in many instances, both in Government and in industry, to decline.

Young engineers with inadequate experience have risen rapidly to management positions. This situation cannot be remedied by applying more dollars indiscriminately to space research and development, nor by adding a variety of new major programs which tend to further dilute available resources and aggravate the management problem.

Under these circumstances, it is imperative that we select systems for development with extreme caution because we cannot afford a proliferation of simultaneous development of major parallel systems or alternate approaches on a major scale.

In some instances, this lack of simultaneity can result in achieving a given goal or objective somewhat later in time. However, this potential tardiness must be measured against the cost required to provide a possible time advantage. In many instances, this time advantage can turn out to be fictitious, if capabilities are spread too thinly over too many programs.

It is extremely important before selecting a system for development, that a precise definition of the job to be done is carefully determined. This definition should include the relationship to other programs and broad objectives, and should include specific objectives and technical specifications as well as a definition of cost, time, and management for the development program. As the program proceeds, there must be periodic and intensive program reviews to assess the continuing program relationships, approach the quality and rate of progress, and to uncover problem areas promptly to insure proper and timely decisions.

These periodic reviews must be performed at a relatively high objective level. In our case, it means at the level of Director of Defense Research and Engineering. This review serves as a forcing function all the way down the line to insure that management is being given priority attention. It may seem that this is contradictory to good management principles wherein responsibility and authority should be delegated to the lowest practical organizational element.

Normally, to simplify management controls and to eliminate unnecessary echelons of review and supervision, responsibility and authority are delegated downward. However, as indicated earlier in the case of very expensive systems, it is imperative that top management attention be given.

Judicious use of resources by the exercise of effective management is another important factor. This includes the effective application of manpower and facilities within the Government as well as in industry. As a management tool, the program evaluation and review techniques utilizing the system called PERT-cost has been devised and is being applied both in Government and in industry. This technique provides improved visibility of the complete program and establishes a systematic approach that is responsive in detail with a very short time constant so that proper management decisions can be made promptly.

Standardization plays an important role in controlling costs for development programs as well as for cutting costs and conserving manpower needed to maintain systems in operations. Standardized parts procurement has been a practice of the DOD for many years. This system must be expanded to include major components, subsystems and in some cases, systems themselves, to improve reliability and reduce costs.

Repetitive launchings of identical vehicles through standardization is one very practical way of achieving improved reliability. Toward this goal, we are standardizing Atlas boosters and Agena spacecraft for both DOD and NASA use. As standardization becomes more prevalent, more of the launch preparation can be accommodated at the factory. Pad checkout procedures can be streamlined permitting more effective pad utilization and shorter on-pad times with attendant savings in manpower and cost.

Reliability itself is most important throughout the development program as well as the life cycle of many operational systems. Lack of reliability has resulted in many program stretchouts in the past. Debugging a system after development is a much more time-consuming and costly operation than designing and testing properly in the early stages of development.

In general, then, we have learned that to control costs we must be selective in the choice of systems for development. This selectivity includes a comprehensive analysis of how and why the particular system fits into the overall defense development efforts and is justified on the basis of its contribution to the overall objective. A precise definition of the job to be done must be evolved. Progress must be assessed on a continuous basis. Standardization must be introduced wherever possible. Reliability must be emphasized throughout the design and development cycle. Management quality and technique must be improved and management disciplines applied vigorously.

Beyond the area of definable application, future technical capabilities, needs and specifications for follow-on systems may not be known adequately enough to warrant initiation of the development of systems. Nevertheless, the lead times involved are so long that development efforts pointed toward achievement of basic capabilities are essential. The economical approach is to develop building blocks of technology which will provide a basic capability with flexibility to move rapidly into systems developments as definition of needs crystalizes.

Examples of these building block developments include maneuverable reentry vehicles; quick reacting, reliable launch vehicles; components for flexible, reusable single or minimum stage to orbit vehicles and orbital research and development stations.

We recognize the necessity for working in harmony with the National Aeronautics and Space Administration, to insure that critical manpower and resources are not inefficiently applied in a duplicatory manner. NASA manpower requirements are reduced by the application of military personnel and facilities where feasible, to dual use in related areas such as the provision of boosters, spacecraft, launch and range facilities. The Department of Defense has not had to increase manpower to accommodate either defense or civilian space programs. This has been achieved by improvements in management procedures and responsibility expansion which, in many instances, results in increased workweeks on the part of our dedicated military personnel, but with no increased cost. In return, we expect to conserve development dollars by the planned use of the results and end products of NASA development efforts such as experience gained from Mercury and the Gemini vehicle itself.

Through the combination of lessons learned the hard way over these years of experience with major development programs, we believe that the cost of space programs can be constrained by concentration of effort on a few high quality major development efforts with clearly defined goals, supported by a vigorous program of building block technology development, coupled with increased attention to standardization and reliability, efficient management and avoidance of dilution of effort and resources which can result from premature initiation of additional major programs, alternative or duplicatory efforts.

This, Mr. Chairman, is a broad summary of our views on how space costs can be minimized or how more effective results for dollars spent can be obtained. I would be very happy to discusss any of the areas in more detail or to attempt to answer any questions you or your committee members may have on specifics or particular programs.

The CHAIRMAN. Thank you very much, Doctor.

I have one question. On the next to the last paragraph you mention—and I subscribe to the thesis:

> We believe that the cost of space programs can be constrained by concentration of effort on a few high quality, major development efforts with clearly defined goals, supported by a vigorous program of building block technology development, coupled with increased attention to standardization and reliability, efficient management and avoidance of dilution of effort and resources which can result from premature initiation of additional major programs, alternative or duplicatory efforts.

Now, in your considered judgment do you believe that NASA—you are in constant contact with NASA—meets this criteria that you set up, or do you think that they have spread themselves too thin on this program on space?

Dr. KAVANAU. Well, sir, we are engaged in moving from one plateau into another plateau of space, which we have described here, and we have numerous studies and efforts underway to see where to go. There are a great number of possibilities. We, in the DOD, are working with the NASA people to provide what advice and counsel we can to insure that those programs are as well defined and as specific as possible. I think that in terms of the major efforts, such as launch vehicles, that this is now being done.

The CHAIRMAN. This is the thing, of course, with which we are concerned. We want the intense effort of the country used in the development of those projects that we feel have great merit.

We realize in doing this we cannot build a maginot line around the space effort and allow no penetration of new thought.

This is the challenge to people, I believe, in management in NASA and in DOD.

You are representing the highest element in that, so this is why I am anxious to get your reaction to this question.

Congress has shown that it is willing to spend money. This committee, along with other committees has supported our national space program; this committee particularly is charged with this responsibility and is anxious to know that we are spending this money to the best advantage of the Nation.

Do you believe this is so, or do you have some suggestion you might make as to how we can save money and yet obtain these results?

Dr. KAVANAU. Sir, I believe that this is so, I believe that in any effort we undertake our objectives must be clear and that we must define and must measure what is necessary to reach those objectives with the least cost necessary.

These programs are very costly. It is possible to introduce many alternative and backup approaches to insure that the programs are accomplished on time. This increases the cost. The question which must be faced every time is to determine exactly when you need a program accomplished and what effort it takes to accomplish that specific job. This is not an easy task, as you well realize. I can say that, as far as the Department of Defense personnel and the people I am in contact with at NASA, great amounts of energy, in many instances over and above what is normally expected, is being given to try to accomplish that job.

The CHAIRMAN. I think that is responsible for the success of the program.

Mr. Fulton.

Mr. FULTON. In your statement you have given figures for research and development expenditures for fiscal 1963 and previously in governmental level.

I would like at this point in the record to have the figures on the other sectors of research and development by private industry, universities, and foundations.

You can give that later.

Dr. KAVANAU. Yes, sir.

(The following information was furnished for the record:)

It should be noted that estimates of research and development funding do vary somewhat depending upon the source of data and the definitions used. Comparability among different years is not always on the identical basis because definitions do change with time.

The R. & D. costs cited earlier in my testimony were drawn from the report to the President on Government contracting for research and development, generally referred to as the Bell Report. Table G–2 from that report is reproduced here:

Federal expenditures for research and development divided between national defense and other programs, fiscal years 1953–63

[In millions of dollars]

Fiscal year—	National defense	Other	Total
1953	2,832	269	3,101
1954	2,868	280	3,148
1955	2,979	289	3,268
1956	3,104	332	3,435
1957	4,027	433	4,460
1958	4,463	523	4,985
1959	5,048	744	5,792
1960	6,639	1,103	7,742
1961	7,719	1,572	9,291
1962	7,820	2,424	10,244
1963	8,572	3,793	12,365

NOTE.—Amounts included in this table under "National defense" for the Department of Defense have been compiled from the best available summary data to provide maximum possible comparability for the years shown.

Current information contained in a recent National Science Foundation bulletin (No. 33 in the series, "Reviews of Data on Research and Development") provides an excellent summary of R. & D. funding by Government, industry, colleges, and other nonprofit institutions.

Sources of funds used for research and development, by sector, 1953–54—1960–61 [1]

[In millions of dollars]

Year	Total	Federal Government	Industry	Colleges and universities [2]	Other nonprofit institutions [2]
1953–54	5,150	2,740	2,240	130	40
1954–55	5,620	3,070	2,365	140	45
1955–56	6,390	3,670	2,510	155	55
1956–57	8,610	5,095	3,265	180	70
1957–58	10,030	6,380	3,390	190	70
1958–59	11,070	7,170	3,620	190	90
1959–60 (preliminary)	12,620	8,290	4,030	200	100
1960–61 (preliminary)	14,040	9,220	4,490	210	120

1 Data are based on reports by the performers.
2 State and local government funds spent for research and development by the colleges and universities and other nonprofit institutions are included with the respective sector's own funds.

NOTE.—With the exception of data for 1953–54 and 1957–58, the years in which surveys covered all sectors data on sectors as sources of funds are estimates.

Source: National Science Foundation, March 1962.

Mr. FULTON. There is one point I would like to make.

NASA has a mission, as has been said by the President of the United States, to place a man, or men, on the Moon in competition with Russia, a peacetime mission, by peaceful methods, for peaceful purposes.

As a part of that mission, however, breaking the mission down, there is requirement now set by NASA for the development of programs for Moon rendezvous and Earth orbit rendezvous.

My question is this:

At the present time there seems to be no military mission, nor weaponry system, involving Earth rendezvous or Moon rendezvous.

Under those circumstances I would like to see cooperation by NASA with the Department of Defense and the various military services.

The question is this: How should the military services participate or observe or be present to get the "fallout" of research and development on the NASA programs of Earth orbit rendezvous and lunar orbit rendezvous?

Would you comment on that, sir?

Dr. KAVANAU. I think I can, sir.

We have a continuous program, as you well know, to study our requirements—our military needs. We in the Department of Defense have a major mission. It encompasses the security of our country. It is necessary that we continually insure that we are studying and maintaining a capability for utilizing whatever technologies are necessary to carry out that mission. In the area of rendezvous, and in general, the space efforts that the country is supporting through NASA, these capabilities are in fact going to the industries, going to the laboratories, throughout the country, and these in turn are fed back to and through our defense establishments.

In a more direct sense, we have military personnel which are, as individuals, assigned to and working with NASA at NASA request.

Major Petrone and others are examples of that.

We have also, as you know, assigned the responsibility for major research and development programs in space to the Air Force. Maj. Gen. O. J. Ritland, Deputy Commander of the Air Force Systems Command, for Manned Flight, has a specific assignment to insure that close-knit knowledge and coordination of programs and plans are worked out at that level with NASA.

We plan to make use of all of the studies and technologies developed by NASA. However, it is vitally important to understand that research and development in the military is not done for its own sake, but it is done as a means to an end, and that is to provide the equipments and manpower in the operations necessary for our military security.

Mr. FULTON. In conclusion then, when NASA has both the research and development mission, as well as an operational mission, in Earth orbit rendezvous and lunar orbital rendezvous, as part of the Moon exploration program set by the President in May 1961, the military services, while having no operational mission for manned lunar landing, nevertheless are vitally interested in the research and development and, of course, to me it seems on that level should be lending personnel back and forth, and should be cognizant of the developments, and should obtain the scientific research and development program of NASA; isn't that true?

Dr. KAVANAU. Yes, sir.

The CHAIRMAN. Thank you.

Mr. Karth.

Mr. KARTH. Mr. Chairman, a statement like this is rather difficult to digest in 10 minutes—at least for me.

I am not sure that the position of DOD is frankly stated here, but I feel it is equivocal in line with what the chairman asked. On page 4, second to the last paragraph, the first sentence, you say:

> We believe that the cost of space programs can be constrained by concentration of effort on a few high-quality major development efforts with clearly defined goals, supported by a vigorous program of building block technology development, coupled with increased attention to standardization and reliability, efficient management, and avoidance of dilution of effort and resources which can result from premature initiation of additional major programs, alternative or duplicatory efforts.

You don't say "are being constrained," you say "can be."

This leads to a question: Do you think NASA has clearly enough defined their goals and that those goals are the proper ones, or don't you?

Dr. KAVANAU. I think NASA's goal in terms of going to the Moon and returning, as set by the President, is in fact a very valid and vital goal.

A major effort in reaching that goal, in terms of research and development programs, is the launch vehicle efforts. In that activity I personally have spent considerable time last year with the Large Launch Vehicle Planning Group jointly set up between the Department of Defense and NASA to assist in determining what the national launch vehicles were going to be. I played a major role there, and I believe that NASA has made the proper selection of those launch vehicles.

It is, I think, a matter of time, to see how these projects progress, and I think we must concentrate on these particular goals, and insure they are achieved as necessary.

Mr. KARTH. So you are in agreement with the goals that have been selected and the way they are proceeding?

Dr. KAVANAU. Yes, sir.

Mr. KARTH. That is all.

The CHAIRMAN. Mr. Chenoweth.

Mr. CHENOWETH. Doctor, in response to the questions of the chairman and Mr. Karth, do I get the impression you are stating to the committee you feel economies can be effected in NASA, in the Department of Defense research, wherever we are spending this money?

I want to commend the chairman of this committee on his effort to promote economy.

That seems to be a forgotten word in recent years. I am glad it is coming back. We are spending a lot of money here. It may be old fashioned to talk about economy, but I think the American people are demanding we start practicing economy.

I think this is a good place to start.

I would be very interested in your statement, as an expert and very close to this, seeing this money being spent, seeing what is being done.

Can we save any money? What can we do? Or is this a wasted effort? The chairman is trying to find some way to save some money.

What is your frank observation on that situation?

Dr. KAVANAU. Sir, I think that money can be saved. The degree of saving is very hard to tell. I think that money can be saved through strong, positive discrimination between those programs that are necessary and those that are not necessary in order to achieve the goals which the Nation has set for itself in the space effort. We should identify those programs and those elements of programs that are clearly needed for carrying those goals and we should fund those programs adequately. Reducing the cost today does not necessarily save you money in the long run.

Mr. CHENOWETH. Congress has been pretty liberal in providing money for research and development.

I think the overall amount is something over $5 billion for NASA and the Department of Defense together this year, as I recall.

Mr. KAVANAU. Yes.

Mr. CHENOWETH. Congress has not been very niggardly in furnishing money for this program. Our problem is, is there any place we can save a little as we go along?

Can we pick up a few dollars here and there and still accomplish the objective?

We are spending billions. There is bound to be some little extravagance or overlapping here, I am sure anyone would admit that. That is elementary. Who is to make this decision? What is the procedure—modus operandi—for trying to effect this economy, what can be done?

Is that our responsibility, is it yours, or NASA's? Where is the responsibility?

Dr. KAVANAU. Sir, I think that this responsibility rests with the people who are given the job to carry out. This is conducted through the management efforts, in terms of details of management controls, costs identification, techniques for reporting, to insure where the moneys are going, and that they are absolutely necessary.

Mr. CHENOWETH. In the final analysis it really rests upon the integrity and desire of the individual to try to save the Government a little money; is that right?

Dr. KAVANAU. Yes, sir.

Mr. CHENOWETH. You have got to depend on his cooperation in that effort.

Dr. KAVANAU. Yes, sir.

Mr. CHENOWETH. You cannot check every expenditure and every move made, you have to rely upon him to take some responsibility of his own; is that correct?

Dr. KAVANAU. Yes.

Mr. CHENOWETH. I agree with you on that, and I think that is a very good observation, Doctor; thank you very much.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. Dr. Kavanau, you have been talking in generalities.

There is something about getting into a Government position that makes you generalize. I feel very frustrated sitting here this morning listening to some of your answers to questions which perhaps are not specific enough.

Dr. KAVANAU. I would like to be specific.

Mr. HECHLER. Couldn't we let our hair down a little bit? We are in this together—you can let your hair down a little better than I can perhaps. [Laughter.]—

Let's take specifically the field of standardization. I think Secretary McNamara has made some laudable efforts in the direction of achieving greater standardization.

Where, specifically, do you think that is being done, or can be done better, in the Department of Defense?

Dr. KAVANAU. I would like very much, if you have the time, to go over exactly what some of our efforts are in as much detail as you would like.

Mr. HECHLER. Would you submit that for the record?

Dr. KAVANAU. Certainly, but I would like to tell you right now instead.

Mr. HECHLER. Tell us what you can. We have about 10 minutes, particularly, regarding the space program.

Dr. KAVANAU. The space program, is one of the areas which we feel is going to produce most effective results for our investment. This means we have to invest in the standardization of products which can be used a number of times. These products should not be optimized for just one job or mission.

Last year we undertook a study of standardized launch vehicles. We foresaw, first, that in the future the Department of Defense would have a great number of launches.

We felt we had to look to the future and to see what our requirements would be, so we would have a truck, a workhorse vehicle, to do this job of boosting payloads into space.

We asked the Air Force and the Institute of Defense Analysis, to study what could be done to standardize our launch vehicles. They both conducted independent studies that showed this could be done, that, in fact, if you were rigorous enough, and firm enough, you could make standardized launch vehicles that might not be optimum, that might not use the most advanced technology, but in fact, utilized building blocks you knew you could build and which could be used over and over again.

Through this effort came a number of programs. The first has been initiated and is underway now—this is the standardized Agena. As you know, the Agena second stage on top of the Atlas is used as a spacecraft and as a boosting stage for a number of programs, both in the Department of Defense and NASA. We undertook a special program to standardize that vehicle such that each vehicle could be made identical to the others, that it would be manufactured and inspected in an identical fashion, so that we could insure reliability this way. This program is now underway.

The Air Force is introducing incentive contracts which provide rewards, which the company gets through progress for improved reliability and quality and reduced cost of the standardized vehicle.

Another program that has been underway is the standardization of the Atlas, which now is used in a number of configurations. We are looking into this standardizing program to insure that every vehicle that leaves the plant is identical with the other.

The third program, and most extensive is the Titan III. In this instance we have sought a standard launch vehicle which could handle the range of payloads from 5,000 to about 25,000 pounds in orbit. In this case, we initially conducted an extensive study, in terms of a standardized program, of what could be done.

We have subsequently undertaken a phase 1 program definition effort, in which we conducted a detailed analysis of everything about this program in terms of costs, in terms of size of effort, in terms of reliability, in terms of incentives, in terms of vehicle performance, and other program details. We have done this. We are studying the follow-on to this effort right now.

We expect, through these standardization efforts, to make sure that every vehicle—and, if possible, major subsystems such as guidance systems—could be used in a number of different applications, but would essentially be made almost identical during manufacture.

Mr. HECHLER. I have only one other question and I will ask it in two parts.

My next question is, since you are a man of great mental acuity and have had excellent training and followed the developments very closely, both on the outside and inside, just exactly what needs to be done, both in the Department of Defense and in NASA, to speed up the application of these things that you have studied and have reached conclusions about with respect to standardization?

Dr. KAVANAU. Well, I can speak for the Department of Defense, I can't speak for NASA.

Our job is to develop space hardware for use. You know the Secretary of Defense is dedicated to this proposition and has a great number of efforts underway to improve our research and development management.

We have in the Department of Defense these three standardized launch vehicles, which are in different stages of development—the Agena, Atlas, and Titan III and now we are looking at major subsystems for standardization. The services are also working closely with us to utilize these and other standardization efforts.

Mr. HECHLER. What are the toughest nuts you have to crack?

Dr. KAVANAU. I think the toughest nut is the fact that the scientist or engineer tends to always look for the best and most optimum solution. We have an advancing technology. It is very hard to ask people who are interested in advancing efforts and advancing knowledge to firm up, to freeze their ideas, and put their program on the drawing board and have it made and have it produced based on known technology.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Dr. Kavanau, you have set a gage in saying that the space program is a new area, but that there are guideposts to follow, that actually the research and development programs are similar—management, complexity, cost, personnel, and that type of thing. Yet, as you go into some of the problems I can't determine whether you are optimistic or pessimistic about our space program.

I would like to hear from you. What parts of the program do appeal to you?

What are we doing right?

What are we doing wrong?

Dr. KAVANAU. Sir, first, I think our space program is right. What we have to do, I think, is to develop a capability and an interest in the country for these programs. I think that we have to make sure that we proceed at a rate which is not detrimental to any other efforts that we have. Our efforts should take advantage of the capabilities that we have developed in various activities of industry, in government, and in the military services, and apply these to our new programs.

Mr. DADDARIO. Are we doing that properly, are we using our manpower properly, or are we diluting our effort?

You have touched on the fact there are people without adequate experience in high management positions because of the minimum number of people involved, because, apparently, you believe we are in short supply.

How has that inhibited our effort?

Dr. KAVANAU. How it has inhibited our effort is a very complicated relationship, of course.

Mr. DADDARIO. Before you get into the answer—the reason I ask is because we have gone into this at some length as we have proceeded through the budget hearings and we have been assured time and again that there is a sufficient supply of adequate people at the right levels to not only manage this program but to conduct it properly at the lower levels.

Dr. KAVANAU. Sir, I have read many of your hearings and I know that you and the committee here, have done a very good job. The important thing is that we maintain consciousness of these problems, in a continuing way and that the responsible managers involved in the Department of Defense—as we are endeavoring to do—in the NASA, and in other Government agencies, insure that we do not neglect the fiscal management responsibilities associated with research and development.

This is the key thing, the maintaining of this responsibility, sir.

Mr. DADDARIO. Are we maintaining it, are we using our best personnel, are we avoiding duplication, is there a proper integration with the National Aeronautics and Space Administration?

Dr. KAVANAU. I think that we are. I think we are endeavoring to.

The problem is big. We are trying to do everything we can, certainly in the Department of Defense, and that is where I can speak, to insure these economies are afforded.

Mr. DADDARIO. What it boils down to is: This is a big problem?

Dr. KAVANAU. Yes, sir.

Mr. DADDARIO. The space objectives are large, we are using our talents and you believe we are using them properly, even though all the answers are not available to us at the moment.

Dr. KAVANAU. That is right; we have to keep on working for those answers, sir.

The CHAIRMAN. Mr. Randall.

Mr. RANDALL. Yesterday, I was not able to be here but I had a secretary make notes, and I believe it was said there was some common library, that all the DOD filters information in it and NASA. Are you familiar with that?

Dr. KAVANAU. I was not here yesterday, but I believe you may be referring to the ASTIA.

Mr. RANDALL. ASTIA.

Dr. KAVANAU. Was that the subject, yesterday?

Mr. RANDALL. What do you think of that?

Dr. KAVANAU. Yes, sir, that is a Government Defense Department function, and we are using that 100 percent.

Mr. RANDALL. Just one other question.

You mentioned the incentive contracts for, I think you said, promptness and rewards for reliability.

On the matter of reliability, this shot at Venus which failed, do you feel there should be something on the other side, if the failure is established, shortcoming or omission, do you feel that there should be a contract of that kind? In other words, something happened down there, we don't know what it is yet.

If the lack of reliability can be established, how do you feel about penalizing a contractor for that?

Dr. KAVANAU. Sir, we are endeavoring in some of the contracts which we are initiating now to put in clauses by which the fees which a contractor receives for the products which they deliver on will in fact be sized by the reliability of products they deliver. If their products have the highest reliability, then in fact they will get more fee. If they work with a little lower reliability this fee is reduced. These are the kinds of measures we are introducing into the incentive contracts.

Mr. RANDALL. I am glad to say and I will say for the witness he has had some pretty hard questions to field and I think he has done pretty well.

The CHAIRMAN. Mrs. Weis.

Mrs. WEIS. No questions.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. Mr. Chairman, I would like to state to Dr. Kavanau, I think his statement is an outstanding one, and a good one, contrary to the impression it may have made upon one or two of my colleagues. I really do think it is an unusually good statement, in that a lot of work has been put on it. It is one that needs to be read slowly and digested to be fully comprehended, I think.

There is one statement that you make, in the next to the last paragraph, page 3, in which you say the debugging of a system after development is a much more time-consuming and costly operation than designing and testing properly in the early stages of development.

Of course, you have already earlier in your statement pointed out that in the year 1958 we spent $5 billion on R. & D. and in fiscal 1963 we expect to spend $12 billion, which would point toward a pretty high cost of debugging.

Could you tell us what debugging covers?

Would you say that all of your missile failures would come in that department?

Dr. KAVANAU. Well, first of all, debugging is not directly coupled with the increase in our research and development budget.

On the other hand, we are endeavoring, and have in some of our missile programs, such as the Titan, to insure that a vehicle does not leave the plant unless it is completed and ready for flight.

In many instances we have had cases where the urgency of the time, particularly when coupled with some of our ICBM programs in the past, required delivering the bird to the cape and endeavoring to make changes in the vehicle configuration after the vehicle was delivered to the cape and ready to fly. We have found that it is probably much better to keep that bird in the plant and fix it up to make sure it is 100 percent ready to go before shipment, and in that way make sure that if there is any correction or malfunction which has to be investigated, that this is done in the contractor's plant and not in the field somewhere.

Mr. DAVIS. Could you hazard a guess, or do you know, what the debugging expense would have been or did come to during fiscal 1962?

Dr. KAVANAU. No, sir; I do not.

Mr. DAVIS. Your statement indicated that it would be greater than the R. & D. expenditure.

Do you mean that literally?

Dr. KAVANAU. Sir, if my statement infers that, I don't mean it.

Mr. DAVIS. It says debugging before development, that is, after you finish with the R. & D., is a much more time-consuming and costly operation.

Dr. KAVANAU. Well, this means effectively the differential of time and cost added on top of what would be the "ideal" R. & D. development program. Where no unusual problem or failure occurs, this is considered an "ideal" development cycle. What this statement means is that if you correct problems in the plant during the design and testing phase, our overall added cost to the development effort would be less than if you waited and debugged continuously after you begin the operational flight program.

Mr. DAVIS. To return to the first question, would you charge a missile failure to the expense of debugging a system?

Where we have a complete failure of mission, such as we had in our high altitude nuclear testing?

Would you say that is a debugging expense?

Dr. KAVANAU. I would not say that that is a debugging expense, until we know essentially what the bug was, sir.

Mr. DAVIS. That is all I have, Mr. Chairman.

The CHAIRMAN. Mr. Fulton has a question.

Mr. FULTON. My question is this: With the same contractors, the same standards of inspection, standards of performance, and in large part the same type of launch procedures and ground equipment, but different locations, why is it DOD has had success with the Atlas-Agena combination and why is there a difference within NASA as to success with the same combination, or lack of it?

Dr. KAVANAU. Well, as you point out, they use the same operation and the same techniques. I believe that the problem arises in the fact that each vehicle is not necessarily identical with the other. This is one of the efforts of standardized launch vehicles which we are endeavoring to go into to make sure that every launch vehicle is the same as the previous one to the maximum degree.

We have endeavored to make a standardized operational vehicle and we can launch these in the same configuration repeatedly.

In some of the NASA programs each payload—and in many instances the launch vehicles—are different, and we don't gain the rewards of repetitive testing of identically the same configuration.

Mr. FULTON. May I say to Dr. Hechler, that his use of the word "mental" acuity, with Dr. Kavanau, caused me to write a poem about Dr. Kavanau.

The CHAIRMAN. We are not going into the poem. [Laughter.]

I think what Mr. Fulton is concerned with, and I am concerned with, DOD has launched 11 Atlases from the Pacific range, and had only 1 failure. But DOD has launched five recently from Canaveral for NASA and only had one success.

Dr. KAVANAU. Sir, the Atlas is the Atlas but there are many different configurations of that Atlas.

The CHAIRMAN. I appreciate that.

It is going to be very hard to explain to Members of Congress that trade names are not standardized.

You have one other question?

Mr. FULTON. At Cape Canaveral I would say three out of four failures.

Mr. HECHLER. Mr. Chairman.

The CHAIRMAN. Yes.

Mr. HECHLER. About a week ago we had a conference with the Navy and Secretary McNamara concerning the installation at Sugar Grove, W. Va.

Do you have any plans, or have you made any progress, toward interesting other agencies in utilizing the investment of close to a hundred million dollars which we will have made in the Sugar Grove installation?

Dr. KAVANAU. No, sir; I personally do not know about that, how far along in the contacts they are and who they are talking with. I do know they are in conversation and touching base with every possible Government agency or group that could make use of it.

Mr. HECHLER. Although I recognize the decision is one designed to save money, nevertheless the investment is so tremendous that I think we should make every effort to see that some other agency of the Government utilize this installation in which we have invested so much money.

Dr. KAVANAU. You can be assured every effort is being made in this direction, sir.

Mr. HECHLER. Thank you.

Mr. KARTH. To make one request of the doctor, Mr. Chairman, for the record, I sometimes feel frustrated in this field of research and development, that we are really not taking advantage of the efforts of other nations as much as we should, because they have some really fine technical people, too.

I wonder if you would put in the record the amount of work and the extent of the work that is being done by the Department of Defense on translation of foreign technical journals and documents and what dissemination you make of this information to other agencies of Government that might use them.

Dr. KAVANAU. I will be happy to do that.

(The following was furnished for the record:)

The Department of Defense has in the three services a rather large effort in the collection and translation of foreign technical information both from technical journals and from other sources. This material is disseminated within the Department of Defense, its contractors, and to other Government agencies such as the National Aeronautics and Space Administration, and the Atomic Energy Commission, by the Armed Forces Technical Information Agency (ASTIA). The general public is served in the field of scientific and technical reports (which include many translations of foreign documents) by the Office of Technical Services of the Department of Commerce.

The CHAIRMAN. Now you may read the poem, if you wish, Mr. Fulton.

Mr. FULTON. Mental Acuity.

Mr. Kavanau intuitively
Uses his mental acuity
With his perspicacity
Equal to his perspicuity.

The CHAIRMAN. I want to thank you for being here, Doctor.

I think you understand what this committee is trying to do and what we intend to follow through on.

Dr. Kavanau. Yes, sir. Thank you.

The Chairman. With that the committee will stand adjourned until tomorrow at 10 o'clock when Mr. George Trimble of the Martin Co. and Dr. Chan Ross of Aerojet General will come before us.

Also additional NASA witnesses will be heard next Tuesday, July 31, at 10 a.m.

(Whereupon, at 12 noon, the committee recessed, to reconvene at 10 a.m. Thursday, July 26, 1962.)

Mr. [illegible]. Thank you.

The CHAIRMAN. With that the committee will stand adjourned until tomorrow at 10 o'clock when Mr. George Trimble of the Martin Co. and Dr. [illegible] will [illegible].

Also additional NASA witnesses will be heard next Tuesday, July 31, at 10 a.m.

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WAYS AND MEANS OF EFFECTING ECONOMY IN THE NATIONAL SPACE PROGRAM

THURSDAY, JULY 26, 1962

House of Representatives,
Committee on Science and Astronautics,
Washington, D.C.

The committee met at 10 a.m., Hon. George P. Miller (chairman) presiding.

The Chairman. The committee will be in order.

Inasmuch as the House goes into session at 11 o'clock today, we will start now and assume that some of the other members will be here soon.

This morning we will hear first from Senator William Proxmire, who appears before the committee at his own request.

We are very happy to have you here, Senator Proxmire.

You honor us with your presence.

It is nice to know that you Members of Congress on the other side of the Capitol will come over to appear before our committee.

We welcome you, sir.

Will you please proceed.

Senator Proxmire. Thank you very much, Chairman Miller. I have with me Mr. Steve Brunner, on my staff, and who has specialized with this. With your permission I would appreciate it if he could sit with me.

The Chairman. Yes, sir.

Very happy to have him here.

Senator Proxmire. Yes, sir.

STATEMENT OF HON. WILLIAM PROXMIRE, A U.S. SENATOR FROM THE STATE OF WISCONSIN

Senator Proxmire. I am appearing before this committee at my own request because I am deeply concerned about the impact of the huge increase in spending for space recently authorized by Congress, and projected future space budgets, on our Nation's other vital needs and goals.

Let me emphasize at the outset that I do not question the importance of our space effort. I support it warmly. I favor the manned lunar program enthusiastically. The significant question is not whether our Nation should undertake a space program—of course it should—but rather at what rate we should carry on such a program and what goals we should establish for our space effort, in relation to the other vital needs and goals of our Nation.

This committee and the Senate Space Committee, as well as the Appropriations Subcommittees that deal with space have done an excellent job of examining the complex details of our present space programs and the National Aeronautics and Space Administration budget for 1963. I want to draw attention, however, to the long-range implications of the space effort, and the many problems that can be foreseen.

These problems may be of great magnitude because, as this committee well knows, the space program's sheer size—in terms of dollars and resources, both human and material—makes it without question the largest undertaking of the U.S. Government since the total involvement of our economy and Nation in World War II.

Already the massive cost and rate of growth of our space program are putting serious strains on our Nation's scientific and defense capabilities, and on scientific education.

Our entire space effort can have staggering effects on our education system, our supply of scientific manpower, our industrial defense capability, and on the American taxpayer.

Comprehensive, detailed study of these effects should be undertaken immediately.

The National Aeronautics and Space Administration already is draining our limited supply of scientific and engineering personnel, thus reducing the manpower available for work in defense, industry, and education. This crucial problem of scientific manpower should be recognized now, and steps should be taken at once to solve it.

A recent article in the Washington Post entitled "Moon Aims Strain Manpower Supply" noted that NASA will need approximately 13,000 more scientists and engineers in the next few years in order to carry out its projected program.

The article went on to say:

> There is now danger that space program recruiters will begin to entice scientists and engineers away from other Government agencies and laboratories and then from universities.

Yet at the same time private industry and the universities will be demanding more scientific manpower in order to carry out their functions.

The question I am asking is this:

Where are all these extra scientists and engineers going to come from?

From our graduating university classes?

Hardly. The proportion of scientists and engineers in graduating classes has been declining for several years and the industrial and especially defense demand for these graduates has greatly increased.

To try to get an answer to this question, I wrote to Dr. Howard A. Meyerhoff, Executive Director of the Scientific Manpower Commission. He replied:

> I have been working on the scientific and engineering manpower problem for nearly 10 years, and even if I apply my imagination to my knowledge, I frankly do not know where these people are (going to come) from, unless we are prepared to cut back sharply on the use of competent teachers in our institutions of learning, and on research and development in industry, and in other Government agencies.

And then Dr. Meyerhoff came to this conclusion:

> * * * NASA's manpower requirements have not been integrated and therefore have not been seen in perspective in relation to other overall needs in education, industry, and government.

This is what one competent authority has to say about how the huge expenditures for our space program are going to affect our supply of scientific manpower.

A specific aspect of our mushrooming space effort that concerns me is NASA's increasing tendency to dispense with advertised competitive bidding in the award of space procurement contracts.

I recognize that certain aspects of the space program may be difficult to operate under the sound discipline of advertised competitive bidding.

But this is by no means the case universally. It has been shown time and time again that competitive bidding is the most effective way to reduce costs and is the fairest to all companies concerned.

Departures from this procedure should be as infrequent as possible, and should only occur when clearly and absolutely necessary.

The use of so-called "competitive negotiation" rather than advertised competitive bidding, while probably preferable to sole-source procurement, nonetheless lacks both of the main virtues of formal competition.

It does not allow all interested firms to compete.

And it does not impose the same solid cost discipline. While I recognize the urgency with which our space program is viewed, I cannot believe that the need for speed is so great that NASA should virtually ignore competitive bidding.

With all the urgency of military procurement, the Defense Department has a far better record on competitive bidding.

Procurement practices and our Nation's scientific manpower are two specific aspects of the larger general problem of viewing our space program in the context of our Nation's priorities and needs.

Several eminent scientists have spoken out against placing an excessive emphasis on a space program. For example, Dr. James R. Killian, Jr., chairman of the MIT corporation, perhaps the Nation's greatest institution of scientific learning, and first science adviser to President Eisenhower, said recently:

> The United States must decide whether it can justify billions of dollars for man in space when its educational system is so inadequately supported.

And further, he warned:

> The Nation must seek to determine whether it is now proceeding too rapidly in this area and whether it can manage the present man-in-space program without weakening other important national programs, including defense.

Along the same lines, a distinguished Member of the House, Congressman Chet Holifield, chairman of the Joint Atomic Energy Committee, stated on a television program last month, in speaking of our space program:

> I have seen what I think (are) very worthwhile programs in applied science, which have direct benefit to the people of America, put on the shelf for the pursuit of some fantastic objective which may or may not be attained 10 or 15 years from now.
>
> And, in the meantime, the people are denied the benefits which are just around the corner.

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It is plain that the massive size and rapid growth rate of our space effort are having the effect of diverting resources away from the fulfillment of other vital needs and goals which merit high national priority.

The task of properly evaluating the relative priorities of these goals must be shouldered by Congress—particularly through its control of appropriations.

I believe that Congress can fulfill this responsibility by more carefully evaluating the enormous expenditure increases that are programed for space, and by cutting back judiciously to bring these programs back into balance with other national priorities.

Certain specific figures may illustrate what I mean.

In the hearings on the NASA budget before the House Appropriations Subcommittee, NASA officials stated that, due to the acceleration of the timetable for placing a man on the Moon, the cost for the Moon project was increased by $7 billion.

This is a fantastic amount of money which will be spent simply to meet a somewhat earlier deadline.

It is a significant part of the many tens of billions of dollars that will be spent in our space programs in the coming decade.

The question that should be asked is whether each of these massive expenditures genuinely represents the best possible use for these funds, collected from American taxpayers, in the general public interest.

As I said before, I do not object to our effort to land men on the Moon. Some protests against the usefulness of this undertaking have been voiced, but I reject them.

Man's ambition has brought him to the brink of a great adventure in space, and our country should indeed work hard to be first with a manned lunar landing.

But our space program should be kept in balance with other national goals. If huge costs are to be incurred, if billions of dollars are to be spent, we should explore the implications of this commitment in advance, with our eyes open, taking every possible step to judge the value of what we will be getting for our investment.

The significant question is not whether we should undertake a space program—of course we should—but rather at what rate such a program is carried on, and what specific goals are set for it.

I urge this committee to examine our space program carefully and set up priorities, both within the program and in relation to other national programs.

I think that we must evaluate which projects in our space program ought to receive top priority and eliminate the projects which do not receive such a rating.

I myself intend to offer amendments to cut back the NASA appropriation in the Senate. In view of the staggering effects which the presently projected space program could have upon education, health, scientific manpower, and even defense, I hope that the committee will be hardheaded and realistic, and prune out projects which it deems to be of secondary importance in our space program.

To help accomplish this I propose these four specific recommendations:

(1) The committee should request NASA to make alternative proposals to show how a slower expansion of funds for the space program

would affect the man-to-the-Moon timetable and other NASA goals;

(2) NASA should provide a justification for the timing of the lunar effort in addition to its item-by-item cost justification;

(3) Procedures should be established to oversee NASA's recruiting of scientific manpower;

(4) NASA should be requested to conform to competitive bidding procedures to the fullest possible extent and should clearly explain the reasons for any exception.

Thank you very much, Mr. Chairman, for this opportunity. I will say of course I understand the whole purpose of this committee's meeting is to explore exactly how the enormously expensive and exacting and demanding space program can be developed with a minimum expense and with a minimum pressure on other very vital and precious resources.

The Chairman. Senator, the object of our meetings is just that. We are as concerned as you, or anyone else, with the great amount of money that is going into the space effort.

We have a responsibility to make sure that this money is being spent intelligently and is being spent in the best interests of the Government.

Now, I think that if you studied NASA's programs, you would find that there are not so many of them, and they are not spreading this money all over the terrain.

It is being directed toward a national program that is being taken in stride. There are constant reexaminations being made in this field; many different approaches are being advanced by competent scientists, both in industry and in our universities and research institutions. NASA has to make decisions on these proposals, and it has made these decisions.

The space program after Mercury will be Gemini.

If Gemini, which involves rendezvous techniques, is successful, it may be that some of the other programs that are now in the process of being examined, which are in no way being funded other than for research and development, will be scrapped.

Now, the question of manpower is one that has bothered me for the past 10 years, or since I first started to serve on the Armed Services Committee—maybe 12 years ago—and we have always been confronted with it.

While fewer people, perhaps, are going into the field of science, yet the number of people seems to be sufficient to meet our present needs, although we would like to enrich our schools and enrich our courses and to bring more people into the field.

And NASA is conscious of this.

NASA has set up a program at 10 universities in the country. They have already started a program to bring people into the field of science, and particularly those scientific disciplines that are most needed.

One of the things that it has done, that I commend NASA for, is this: of the 10 people who will constitute each one of these panels at the various universities, at least 2 must be economists. So that we are not turning this thing over to one group which cannot evaluate the economic consequences involved.

NASA is trying to study the effects it will have on the economy, along with the development of its initial objective of the total space effort.

Now, the jurisdiction of this committee varies a great deal from the jurisdiction of the committee in the Senate.

Ours is the Committee on Science and Astronautics. We have legislative jurisdiction directly over the National Science Foundation and are just as concerned with its work.

We also have jurisdiction over the Bureau of Standards, one of the greatest scientific institutions in the country.

We have jurisdiction in all fields of scientific research and development.

We are looking at many of these things. This committee recently held hearings on Hovercraft, something little known in this country, but on which the British are spending a great deal of money, and have already got a craft that is going into operation on the River Dee as a tryout and test. When I was in England last year, they made no bones about it, they hope to develop this thing as a new means of transportation that could then be offered for sale not only in Europe but in southeast Asia.

I think we have slipped a great deal in this particular field.

We are also very much concerned with hydrofoil craft.

We have had several meetings on this subject.

I do feel that, although we are now getting along pretty well, that we had slipped and that we were behind in its development, and if we are going to keep abreast of the other nations of the world, we have got to have these things; other nations will support them.

We are also conscious of the manpower problem, and we would like to solve it.

I just tell you these things, not to argue with you, but to show you that we are conversant with the impact of the things that are taking place.

I believe that if there are going to be cutbacks in our national goals in this field somebody should come to us and prove his case. We are satisfied with the program as it now stands. We are going ahead, not going too fast in our judgment. We are trying to hasten at a speed that will give us the best results for the dollars that we spend.

We hold these hearings to act as a watchdog over NASA, to make sure that the money that they are spending is spent to the best advantage of Government. And in this respect too we exercise some control over the R. & D. in the Department of Defense.

We regularly have Department of Defense people before us.

We are particularly concerned to make sure there is full coordination between NASA and DOD, and no duplication in this field.

This is one of the places where waste can take place.

Now, as far as NASA's contracting is concerned, this is an entirely new field, it is very hard to write contracts in this area. It is about in the same position that the airplane industry was 15 years ago—or at the outbreak of the war, and it look a long time before we could reach the point where you could tighten up; and even today, in certain phases, DOD has been unable to come up with formulas where it doesn't have to negotiate contracts.

I realize that the closed end contract is to the best interest of the Government when those contracts can be written. Experience has shown where you have to make departures they get very expensive.

Any questions?

Mr. Hechler?

I have taken too much time myself. I did want to answer some of the Senator's arguments. The House is going to session at 11 o'clock.

Mr. Hechler. I was deeply interested in your statement, Senator Proxmire, even though there are parts with which I disagree.

I share your concern about the departures from competitive bidding.

I think considerably more has to be done, as you suggest, to follow some of the experiences the Defense Department has given us in this area.

On scientific manpower, I would like to push your thinking back a little bit here.

What relation do you feel an investment in our general educational system has to the strength of America's space program in the future?

Senator Proxmire. I think it is extremely important. The great difficulty—if I could at the same time answer one of the points raised by the distinguished chairman—is that the NASA educational program is a program for training people, as I understand it, pretty much at the graduate level, or even at the post, postgraduate level.

Our difficulty is that we have to do all we can to persuade more people to go into science at the high school level and at the college level.

Here, I think, is where we are really losing ground.

Nicholas DeWitt's study, comparing our scientific education with that of Russia, is alarming.

I think the President was right to bring it to the attention of the country. Ten years ago we were graduating more scientists and engineers than the Soviet Union. But now we graduate some 45,000 per year to their 125,000. Our experts tell us their graduates are of equal competence.

I think you are correct. We can best solve this problem by doing all we can to encourage and improve and expand education at the lowest possible level, surely at the college level at the very minimum.

To try to solve it by having fellowships, and so forth, at the top level would serve a particular defense or space program, perhaps, but would not solve the basic problem of training adequate scientific manpower for the future.

Here is where we are most vulnerable in our contest with the Soviet Union.

I know we are ahead in military power. We are far ahead in economic productivity. But we are being challenged in the area of scientific manpower training.

I think that can't be overstressed.

Mr. Hechler. Is it your point that the emphasis now is preempting funds which should be diverted?

Senator Proxmire. I am concerned about funds, of course. I think we have to be. But I am even more deeply concerned with scientific manpower. I think there is a very great possibility, where there is this enormous demand for scientific manpower by NASA and its contractors, I think it can have the effect of taking scientists not only from Defense research work, but also right out of the universities, scientists engaged in graduate education and undergraduate education now, and in doing that, cripple our longrun space program, our ability to continue to surpass Soviet Russia in the future.

I think it is an important program. I would want very much to have us first on the Moon. But I think we should establish a thoroughly understood system of priorities so that we do not cripple our scientific education at the same time.

Mr. HECHLER. I compliment you, Senator, on this provocative statement. It presents a lot of fresh thinking to our work in this area, even though it is controversial.

Senator PROXMIRE. Thank you.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. I agree with you on your statement, where you say that we must have more competitive bidding. I think that is an excellent approach.

You say:

> I recognize that certain aspects of the space program may be difficult to operate under the sound discipline of advertised competitive bidding. But this is by no means the case universally. It has been shown time and time again that competitive bidding is the most effective way to reduce costs and is the fairest to all companies concerned.

I compliment you and agree wholeheartedly on that statement.

The question appears to be, from your position, whether we cut back the research and development and scientific programs of this country, or whether we increase the base, foundation of education, and go ahead.

I take the opposite course. First, I have not seen any testimony to the effect that we are short of scientists or engineers in this country for the current projects in the Government budget or for private business research and development.

So the shortage has not occurred yet.

In my own city of Pittsburgh we have a space academy which operates outside of regular school hours where we have 3,000 young people enrolled who would not otherwise be interested in science.

So that space projects do generate interest in science and scientific education.

Rather than being limiting, I think they will be expanding the base in the future tremendously.

Senator PROXMIRE. Could I answer that at this point, Mr. Fulton?

Mr. FULTON. I would be glad to have you.

Senator PROXMIRE. I would like to refer to the statement by Dr. Howard Meyerhoff, Executive Director of the Scientific Manpower Commission, to whom I wrote on this question.

Mr. FULTON. I saw that.

Senator PROXMIRE. I want to quote this once again.

> I have been working on the scientific and engineering manpower problem for nearly 10 years, and even if I apply my imagination to my knowledge, I frankly do not know where these people are [going to come] from, unless we are prepared to cut back sharply on the use of competent teachers in our institutions of learning, and on research and development in industry, and in other Government agencies.

We have all kinds of evidence—which I put in the Congressional Record—to show there is pirating going on back and forth.

NASA has lost top scientific people, has taken such people. There are far more jobs available, as I am sure you realize, for scientific graduates these days than there are people to fill them.

Mr. FULTON. No; I have not found adequate evidence of that shortage. I must disagree with you.

I think the position of Dr. Meyerhoff is that the shortages are coming in the future. If you read his statement closely I believe you will find that to be the case.

May I go on further?

Senator PROXMIRE. Yes, sir, although I vigorously disagree on your interpretation of Meyerhoff.

Mr. FULTON. I would disagree with you that we must eliminate every project except those of top priority in space.

That would, obviously, knock out every bit of space basic research in this country.

I cannot agree with you on your disagreement with the President of the United States in his statement of May 1961, in which he set the Moon project as a national goal. He is my President and he is your President, and if we do not really stay in the race, why, then we are out of it.

You cannot have one foot in the race to the Moon and then say "Well, we have these other things to do, maybe we better slow up."

I am going to look into the $7 billion cost increase about which you spoke, because before this committee I have not heard such a cost figure as additional cost for moving up the timetable on the space program. Maybe the budget will require about the same amount, but more quickly.

Senator PROXMIRE. I will give you the exact citation. Page 890 of the House hearings; testimony of Mr. Wyatt.

Mr. FULTON. The President says:

> First, I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth. No single space project in this period will be more exciting, or more impressive to mankind, or more important for the long-range exploration of space, and none will be so difficult or expensive to accomplish.

Now, in the House of Representatives, on passing this budget, after that comment of the President making it the goal, our House of Representatives adopted our space program 1963 budget by 342 to 0 on a record vote this year.

So that I believe we are committed.

Senator PROXMIRE. I would appreciate an opportunity to answer, and say I support this program, I voted for it, I will vote for it. I say it is a matter of timing, of the priorities, a matter of trying to do this in some different way and having alternatives available to the Congress.

Mr. FULTON. I agree with the President and I disagree with your position.

Here is the other point:

We have these things that are of tremendous interest, such as the communications Telstar satellite, the Advent program, the Notus navigation satellite, Nova, Tiros, Nimbus, and so forth. We have many other space programs of practical use that will mean billions of dollars saving to this country.

Should we stop them?

Senator PROXMIRE. No. I don't say that I have other programs. All I say is we should establish priorities and recognize that when we proceed with this nondefense effort for a man on the Moon, that in doing so we are very likely to prejudice our ability to move as rapidly as we should in defense and in education.

I am not, of course, in any position to say which program we should knock out. I would never say we should knock out every project for basic research.

I say we should proceed with more information than we have, with the system of priorities, in a much more deliberate way than to say pretty much "the sky is the limit" on this man-to-the-Moon program.

Mr. FULTON. The weather satellite program will save us a billion dollars a year.

We would be able to predict drought, floods, and hurricanes.

In one of the Tiros programs already we have saved hundreds of millions of dollars, in Texas, on that tremendous hurricane that took place, with less damage and the least loss of life of any major storm because of the advance notice from a satellite.

You would not stop that program, would you?

Senator PROXMIRE. No. What I say is that we should have far more information than I feel we have now. This program has not been challenged in the Congress. It badly needs to be.

Nobody has insisted we have a clear opportunity to judge whether we go to the Moon 6 months earlier or a year earlier than we had planned.

Mr. FULTON. The President has said we have that plan as a national goal.

Senator PROXMIRE. And in doing so perhaps save $7 billion. He is my President too, but I can disagree with him, as I often have.

Mr. FULTON. He has my Republican support this time.

Senator PROXMIRE. I am sure he has.

Mr. FULTON. As we finish, may I point out, the country which first gets a manned, operable, maneuverable spacecraft will probably have a tremendous strategic and security advantage in this world.

One of the problems we have on getting to the Moon is how to rendezvous in Earth orbit, how to get maneuverable spacecraft, and how to get direction and control, and how to advance the life sciences.

That is a tremendously broad base for any program. It likewise has a security aspect that should never be overlooked.

For U.S. security, we cannot afford to have any adverse country, that would take us over, have a maneuverable spacecraft that could destroy any city in our country within an estimated 9 to 20 minutes.

You certainly would not hold up 1 minute on that part of the lunar space program, would you?

Senator PROXMIRE. Well, I would say, with Dr. Harold Brown, Director of Defense Research and Engineering for the Defense Department, McNamara's top adviser, there is as yet not definable military need for manned space vehicles. He even had some doubt manned space vehicles would ever have a military use.

It is a possibility and perhaps a remote possibility.

Mr. FULTON. We are pushing the Department of Defense to wake up—on this committee.

There is this tremendous challenge in space, as the President has said, and, secondly, I will speak for myself—I think there is a strong security reason to prevent any country from getting a maneuverable spacecraft when we don't have it—that could destroy our cities in somewhere between 9 and 20 minutes.

So that if the Department of Defense has not wakened up to that, some of us have, and, therefore, we need this program of $4,800 million as much as we need the $48 billion defense program, to me, and if you want to cut anything, why don't you come in here—in all good humor—and say cut the foreign aid program?

Senator PROXMIRE. I will vote for cuts in the foreign aid program. I have in the past.

The CHAIRMAN. Anyone else?

Time is going. We haven't very much time. The House goes in session at 11 o'clock. We have two other witnesses.

Mr. KARTH. I would like to say this, Mr. Chairman, so the Senator and I better understand the Nation's efforts in space.

I appreciate your concern about the establishment of priorities. I would like to say, however, that, as a member of this committee, it has come to my attention that the national goal we have established; that is, to put a man on the Moon and return safely, that all of the priorities that have been established lend themselves to the acquisition of this goal.

The manned lunar landing program, for example, which constitutes about two-thirds of the total NASA budget this year, is really a misnomer. I had the subcommittee that looked into the budget requests of the Office of Space Sciences. I found during our investigation, for example, that about three-fourths of all the funds in that area lend themselves to a successful manned lunar-landing-and-return project.

I know that the Hechler subcommittee on data acquisition and tracking found that this, too, lends itself to the successful completion of the manned lunar-landing-and-return program.

So I would estimate that about 90 percent of all the funds this year, Mr. Chairman, that are being requested by NASA, are being requested to accomplish the very thing that you are in support of, and the very thing I am in support of.

I am in support of the manned lunar landing program, not necessarily because of the physical act, which, true enough, is sensational and will certainly lend prestige to the Nation, but I am interested in it because I see there are going to be a lot of byproducts that we can make a tremendous use of in the future economy of this country, Senator.

I am sure all of this scientific and technological effort going into the manned lunar landing program is going, in the long run, to develop new sources of power and bring about the construction of new factories and new products, and these in turn will bring about new jobs and new opportunities.

So I really see this program, sir, as one tremendous national objective to lift our standard of living, if you will, and make this a better economy by which the American people can live.

Senator PROXMIRE. We do not disagree one bit. It is a matter of time, and it seems to me if there can be a difference, as Mr. Wyatt testified, of $7 billion, whether we are there a little earlier, these byproducts, which you say are extremely important to us, will still be enjoyed.

It is a matter of doing this in the most economical way and still pushing along as fast as we can.

Mr. KARTH. I appreciate your concern, Senator. I may say I have the same concern. We could drag this thing out, I suppose, and seek this objective in 1980 and probably save $14 billion. Whether it would be good to do that to save $14 billion, I think I would probably argue with you. Whether we should slow it down to save $7 billion, I am not sure that would be wise either.

Senator PROXMIRE. I am asking only that we want from NASA alternatives so that we can know how much we can save if we proceed on a different schedule. I want to have this kind of information so we can make an intelligent choice. We can't do that now. We move ahead full speed with no chance to select alternatives based on information.

The CHAIRMAN. Mr. Riehlman.

Mr. RIEHLMAN. I want to say this, Mr. Chairman:

I commend the Senator for a very interesting statement. There are some areas in which I do disagree with him.

I concur with him in the fact we want to watch this program. We certainly want to cut out every bit of duplication and waste, and if we can save money we will save it.

I am alarmed at the statement where, apparently, Mr. Wyatt has stated to another committee that NASA could save $7 billion—or that they will spend an additional $7 billion because of the acceleration of this program.

Mr. Chairman, I think this is an important point. I don't think we have had any such testimony. I think we have tried our level best to secure information from Mr. Wyatt and other people from NASA as to what the additional cost would be to accelerate this program.

I think we better have those people over here to tell us the true facts; if they tell the Appropriations Committee one thing and tell us another, that is a little bit of a difficult situation. This committee has the annual authorization bill, and, as has been stated here today, we took it to the floor of the House and carried it unanimously. There wasn't a dissenting vote. And now we learn there is a possibility that because of acceleration it will cost $7 billion more.

The CHAIRMAN. I direct counsel to make note of this and to insert in the record of these hearings material which will clarify this matter.

Senator PROXMIRE. Citation is page 890 of the hearings.

(The following is testimony extracted from p. 890 of pt. 3, hearings before the Independent Offices Subcommittee of the Committee on Appropriations, U.S. House of Representatives, 87th Cong., 2d sess.:)

COST OF ACCELERATING LUNAR LANDING PROGRAM

Mr. RHODES. Dr. Dryden, as I understood your statement about getting to the Moon, you said there was a new decision made to get there in 10 years. Actually, was not the decision to get there before 1970?

Dr. DRYDEN. Yes, by the end of the decade.

Mr. RHODES. What was the old timetable?

Dr. DRYDEN. The old timetable simply put it somewhere beyond 1970. We thought we would reach the stage of circumnavigation of the Moon by 1970.

Mr. RHODES. How much money would you say is in this buget which would not be there if it had not been for the decision to accelerate the Moon program?

Dr. DRYDEN. I have forgotten the figure.

Mr. WYATT. This budget probably has two and a fraction billion dollars directly chargeable to the acceleration of the lunar program.

Dr. SEAMANS. Some would have been there anyway. Of the total, $2.6 billion is for manned space flight, but some of it would have been there if we had not made the decision.

Dr. DRYDEN. This is difficult to say because you may recall that in Mr. Eisenhower's budget message he said he wanted to study further whether we should go beyond Project Mercury. If you interpret that literally, the great majority of this $2 billion comes from the decision to go to the Moon.

Mr. OSTERTAG. $2 billion?

Dr. DRYDEN. $2.6 billion for manned space flight. Mercury has a very small amount in here.

Dr. SEAMANS. Some of it was for Saturn and was already included.

Mr. OSTERTAG. The $2.6 billion you speak of it not entirely in this bill?

Dr. DRYDEN. Yes, it is. Of the $4 billion, about half is associated with the decision to push forward with large boosters, manned space flight beyond Project Mercury. This is accurate.

Mr. OSTERTAG. You are fully funding for that?

Dr. DRYDEN. No.

Mr. OSTERTAG. How can it all be there, then?

Dr. SEAMANS. This is for 1963.

Dr. DRYDEN. If the decision had stuck, we would stop manned space flight having put Glenn around once, you would not have this $2 billion here.

Mr. RHODES. As I understand, the full cost is about $7 billion.

Mr. WYATT. That was $7 billion over what we had projected we would spend in getting there more slowly.

(The following letter of explanation was received from Mr. D. D. Wyatt, Director, Office of Programs, NASA:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., July 31, 1962.

Mr. FRANK R. HAMMILL, Jr.,
Counsel, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. HAMMILL: In a statement before this committee on July 26, Senator Proxmire referred to my testimony on page 890 of the NASA hearings before the Independent Offices Subcommittee on Appropriations in which, in reference to the manned flight program, I stated: "That was $7 billion over what we had projected we would spend in getting there more slowly." That statement referred to the increase in expenditures in this decade as a result of the Administration's decision to accomplish manned lunar landing and return before, rather than after, 1970.

This matter of program funding increases associated with the accelerated manned lunar landing program was taken up before the Committee on Science and Astronautics in the 1962 NASA authorization hearings. On page 1043 of the 1962 hearings Dr. Hugh L. Dryden, Deputy Administrator of NASA, stated: "On the assumption that we were going to the Moon after 1970 under the original plan, this represents a moving forward of the goals, and a resultant increase of cost in this decade of $7 to $9 billion over what would have been spent had we been content to proceed at the slower rate." It was to this same matter, that I referred in my testimony this year before the House Appropriations Subcommittee.

It is a complex question whether the additional moneys required in this decade for the accelerated program will, in fact, result in an ultimate increased cost of accomplishing manned lunar landing and return as compared with the slower program pace envisioned prior to May 1961. On either time scale, substantially the same development efforts and the same specific tasks would have to be accomplished. The program costs on either time scale are largely determined, therefore, by the rate and duration of application of industrial effort to the solution of the technological tasks.

For any individual task, an optimum time schedule can be qualitatively determined. In general, a minimum technical effort is required to make any progress. If the applied effort is at, or only slightly above this minimum level then the time required to accomplish the task will be long and the overall cost in terms of total contract effort will be high. On the other hand, if too short a time scale is scheduled for the task accomplishment, it will be necessary for the contractor (and subcontractor) to employ very high rates of manpower and the total cost again will be high. An optimum intermediate time schedule therefore exists in which the moderate contractor effort over the time required can be expected to result in minimum total cost.

Qualitatively the considerations regarding a single task element can be extended to cover as complicated a project as the manned lunar landing. Here again, an optimum time exists to accomplish the multiplicity of interrelated research and development tasks. A precise definition of the optimum total time schedule is not possible at this time. It is, however, our belief that the goal of a manned lunar landing within this decade will probably result in no more total project cost than would the slower prosecution of the same tasks aimed at a comparable goal in the 1970's.

I hope that these viewpoints will help clarify the meaning behind my statement which was quoted by Senator Proxmire.

Sincerely yours,

D. D. WYATT,
Director, Office of Programs.

Mr. RIEHLMAN. The other point is: I heard the very same statement made by Dr. Brown—he has been before my other committee—in respect to the Defense Department's position in space; but I have interrogated, under Mr. Teague's subcommittee, a witness from the Department of Defense, and they do have an interest in this, and a definite interest.

They have not yet said what it is. But I will call to your attention this item—written by a reputable reporter, Mr. Stewart Alsop, who says that outer space is the next battlefield, and the DOD recognizes it.

So that the $3,700 million we are putting into this program is not the purpose of simply landing a man on the Moon.

The spinoff to our national defense posture will probably be much more important to our survival as a nation than just putting a man on the Moon.

I think that it is time that the Department of Defense says so publicly. Just the day before yesterday Dr. Brown was before my other committee—I did not get into this phase of the program, but it is about time they come out and tell the people they do have a definite interest and a program which they have not yet exposed to the public.

Senator PROXMIRE. It is my understanding that the Defense Department spends about three times as much on space as NASA does and that the military applications of space are, in the Defense Department now, of enormous proportions; and appropriations for space to Defense show this, as you know, for their missile program.

While there may be this future application of manned flight to military action in space, it does seem, at the present time, at least, to be somewhat remote.

I would agree with you it would be a great service if the Defense Department would come forward and say what specific application this can have.

Mr. RIEHLMAN. I do not agree it is remote. I think it is of primary interest as of today to them. They are not admitting it as of yet, but they will have to admit it.

As I say, just day before yesterday we were talking to Dr. Brown about this very same thing, on our other committee, the fertilization of information across from the Defense Department to NASA, and we are trying to see that this thing is carried out properly, that there is no duplication or waste of effort in the scientific field—which you and I are both interested in.

The CHAIRMAN. Who is the chairman of the other committee?

Mr. RIEHLMAN. Mr. Holifield, who is just as interested in the field as I am.

The CHAIRMAN. I just wanted to get that for your information, Senator.

Senator PROXMIRE. Very good.

Mr. RIEHLMAN. We spent 2 days with Dr. Brown. We are as interested as you are in the Senate in trying to save money and avoid duplication of activities between the Department of Defense and NASA. Our hearings were held for that specific purpose—to find out what will happen in this great field of research and development, where we are spending $12,900 million a year. It is tied into one package when we get to the defense of our country. It is just as important that we move along. I don't want duplication or additional expenditures. I am perturbed that the Department of Defense—and I am not trying to be political—does not come out and say that we do have a definite military need in this field, because it is there and they know it.

In executive session, in which Mr. Teague was chairman, we learned some of the things they are not telling the public, and it is about time we knew it.

We have to have a reporter come out and tell us about it.

In a few weeks we will be told that is probably the position of our Department of Defense and the administration.

Senator PROXMIRE. Mr. Riehlman, let me answer in two sentences. The first two recommendations I made to the committee were that the committee should request NASA to make alternative proposals to show how a slower expansion of funds would affect the man-to-the-Moon timetable and other NASA goals.

I am asking for information. Secondly, NASA should supply a justification for the timing of the lunar effort in addition to the item by item cost justification.

That is all I am asking for.

Mr. RIEHLMAN. You have the right to ask it. I think the implications would be entirely different. It appears you want to slow the program down and that there is a possibility of saving a great amount of money. I just do not think you will save this money, because the spinoff will be so much better to the Department of Defense, whom I think are just as interested as we are in putting a man on the Moon—much more so. That is all, Mr. Chairman.

Mr. FULTON. You can see this committee is interested in space.

Senator PROXMIRE. It is indeed.

The CHAIRMAN. Senator, I do not know of any committee I have ever sat on in the House in the 18 years I have been here that has taken their duties in passing an authorization bill more seriously than did this committee this session.

Mr. CHENOWETH. Well said.

The CHAIRMAN. We had four subcommittees that worked simultaneously for many weeks. Their meetings were well attended. I think that very little got by these committees.

I think this is agreed around the table. If there is anyone—any of the members serving on other committees—who can say he has ever served with more dedicated people, I would like to know what committee it is.

And we are interested in the very things you are interested in.

Mr. FULTON. It takes a lot to put our friend Mr. Riehlman in orbit but he certainly is today.

Mr. RIEHLMAN. May I say this, Mr. Chairman: I am not in orbit.

I hope that both of my feet are solidly on the old terra firma, but I am trying to be objective and bring to this committee some of the knowledge I have besides just what we hear in statements.

Mr. FULTON. I agree. I think you did well.

The CHAIRMAN. Senator, I want you to know that we appreciate your being here.

We do have this common interest. We realize there is a great amount of money being spent. Maybe we don't share the same apprehensions that you do.

I heard this thing about our scientific manpower 10 or 12 years ago, but still we are getting along.

If the number of people that come to me that want to get jobs in the industry is any indication, there is no shortage at the present time. I assure you I have got a list of a dozen engineers and scientists, and if any of the people in Martin-Marietta or Aerojet want to pick them up, I will give them the list.

There has always been piracy in the scientific lines in the aircraft industry.

As a matter of fact, one general manager told me once that the companies in the Los Angeles area would be much better to take one page in the paper and sign all their names to it, and have one clearinghouse, rather than to work the way they did.

This is beside the question.

Very happy to have you here, Senator.

Senator PROXMIRE. Thank you very much, Mr. Chairman. I have enjoyed it a great deal. This is a mighty stimulating committee to appear before. [Laughter.]

The CHAIRMAN. Don't tell me that there are no committees in the Senate that don't give you the same stimulus?

Senator PROXMIRE. Well, they usually don't have this much spirit. [Laughter.]

The CHAIRMAN. Thank you.

That is a great compliment.

Mr. FULTON. We have enjoyed having you.

The CHAIRMAN. We have enjoyed having you and want you to come back at any time.

Gentlemen, it is now 5 minutes to 11. Unfortunately the House will meet at 11 o'clock.

We have two witnesses scheduled to appear this morning, and it is not fair to ask these men to come here just to file their statements.

Mr. Trimble and Dr. Ross, could we schedule your appearance for some day next week?

Could you come back?

We would like to hear you. We would like to hear you in depth, not just briefly. Unfortunately, I am certain that within 5 or 10 minutes at the outside the bells will ring, and the Members will be called to the floor of the House.

We just happen to be caught with no prior knowledge that the House would meet at 11 o'clock today, and I'm very sorry if it has inconvenienced you. If it is satisfactory with you, I will ask Mr. Hammill to correspond with you gentlemen to determine a date that is acceptable to both of you for your later appearance. I want to thank you for being here. I hope you understand our position and our predicament. The committee will stand adjourned subject to the call of the Chair.

(Thereupon, at 11 a.m., the committee adjourned, subject to the call of the Chair.)

WAYS AND MEANS OF EFFECTING ECONOMY IN THE NATIONAL SPACE PROGRAM

TUESDAY, JULY 31, 1962

House of Representatives,
Committee on Science and Astronautics,
Washington, D.C.

The committee met at 10 a.m., Hon. George P. Miller (chairman) presiding.

The Chairman. The committee will be in order.

This morning we resume our hearings on ways and means of effecting economy in the national space program. We had hoped to hear from this morning's witnesses at an earlier date. However, as frequently happens, the members had many questions they wished to ask our first few witnesses, and we had to reschedule these gentlemen.

This morning we will hear from Dr. John F. Clark, Associate Director, Office of Space Sciences, NASA; Mr. G. M. Truszynski, Deputy Director, Office of Tracking and Data Acquisition, NASA; Mr. James E. Sloan, Director of Integration and Checkout, Office of Manned Space Flight, NASA.

I notice Mr. Wyatt is here again today. He is Director of the Office of Programs.

We want to welcome all of you, gentlemen.

Mr. Wyatt, whom do you want to start?

Mr. Wyatt. Mr. Chairman, if it is agreeable with the committee, we would like to have Mr. James E. Sloan start. He has a very important meeting this morning he would like to attend after he is through here.

The Chairman. We are very happy to hear you, Mr. Solan.

STATEMENTS OF JAMES E. SLOAN, DIRECTOR OF INTEGRATION AND CHECKOUT, OFFICE OF MANNED SPACE FLIGHT, NASA., AND D. D. WYATT, DIRECTOR, OFFICE OF PROGRAMS, NASA, AND DR. RICHARD MORRISON, DIRECTOR OF RESEARCH, VEHICLE AND PROPULSION PROGRAMS, OFFICE OF SPACE SCIENCES, NASA

Mr. Sloan. Mr. Chairman and members of the committee, I have a prepared statement which I would like to go through. We have some view graphs to highlight some of the points I would like to make.

My presentation today will describe some of the activities in the manned space flight program that we have initiated to insure successful achievement of the goals of our manned lunar program, with the minimum expenditure of money and time. My own area of responsibility deals with the integration and checkout work being accomplished at our field centers and here in Washington, and I will describe this effort to you now.

Integration.

First, a definition of "Integration" is in order.

As used today, it means "the establishment of methods and procedures, and the necessary technical direction to insure the compatibility of major system elements."

Because of the enormous size and complexity of the lunar exporatory program, the design, development, production, and test effort has been assigned to a very large number of contractors, dispersed over a broad geographical area.

These contractors in turn are directed by several of our field centers which are geographically separated.

The work on all stages of the space vehicle is concurrent, meaning that many parallel development programs are in progress at the same time.

The need for tight control and integration of this large development effort is readily apparent. This must be accomplished at all levels of the design program in order to—

(1) Avoid duplication of design effort.
(2) Avoid redesign at the launch site.
(3) Avoid last minute crash development programs to pick up overlooked system elements.

Meticulous across-the-board examination of the space system as its design evolves during the development is absolutely vital in order for us to make efficient use of the financial resources available to us, and allow us to reach our lunar landing goal within the established schedule.

Some of the methods and procedures we have established to achieve the objectives in the area of integration are associated with the following:

(1) Integration panels.
(2) Design reviews.
(3) Design standards.
(4) Documentation standards.
(5) Configuration standards.
(6) Terminology standards.
(7) Functional diagrams and system descriptons.

It is hardly necessary to describe the great potential savings available to us through across-the-board standardization in the design, documentation, and terminology areas.

It is a outright waste of scarce, talented engineering and scientific manpower to allow designers to do the same job over again at another location just because the knowledge that another engineer had already solved his problem was not available to him when he needed an answer.

In all of the standards areas, we are borrowing heavily from past Department of Defense experience where their work is applicable to our space problems.

The CHAIRMAN. May I interrupt here?

Mr. SLOAN. Yes, sir.

The CHAIRMAN. I think this is fine, but just how, practically, do you do this in the field?

How do you make sure there is not duplication by the man who has a problem to solve and starts working on it and then finds it has already been solved?

Do you have a central clearing agency?

How do you go about doing this?

I think it is quite important, but I think it would be interesting to get it in a little more detail.

Mr. SLOAN. If I might, I could perhaps go through the next 2 minutes or so of our statement here and then I could respond after that.

The CHAIRMAN. All right, fine.

Mr. SLOAN. We have set up integration panels in all of the important technological areas to identify and resolve interface design problems, where a decision on the part of one NASA center or contractor can effect the design effort of another.

These integration panels consist of working level engineers from the Marshall Space Flight Center at Huntsville, the Manned Spacecraft Center at Houston, the Launch Operations Center at Cape Canaveral, and the Office of Manned Space Flight in Washington.

Although these sessions are organized and directed by NASA, contractor representatives participate when they are needed to contribute to the solution of a specific problem.

Each NASA center conducts regular detailed design review sessions with its contractors, thereby insuring that decisions and technical policies established by the integration panels are implemented throughout the development program.

The contractor's own effort to fulfill his responsibility to produce an integrated design in his system or subsystem are monitored closely, and he is assisted as necessary to identify and resolve system incompatibilities and difficult design compromises.

I think in part this will answer your question, Mr. Chairman.

We are producing overall system descriptions and functional diagrams that tie together at one central source the "as designed" system information.

We have a complete record of all of the specific equipment and hardware designs as these designs evolve.

We will put this all together, publish it and make it available to all of the people who are working on the Apollo program.

This means that if there is, for example, an operational amplifier being developed at one of the North American plants by an engineer there, and the same kind of development is, for example, to be undertaken by the people up at MIT, each will have access to the work of the other.

We will keep this current and update it as best we can throughout the whole life of the program.

Mr. KARTH. Mr. Chairman, may I ask a question?

The CHAIRMAN. Yes.

Mr. KARTH. What is NASA doing about retrieving and translating foreign technical journals that may well have answered problems before any American contractor has done work on it?

Mr. SLOAN. There is an Office of Technical Publications in the headquarters activity that is accumulating and publishing abstracts and listings of documents from the available publications.

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Mr. KARTH. Is NASA a regular recipient of this publication?

Mr. WYATT. We are not only a recipient of the translation efforts conducted in the Department of Defense and made availabe to us through such agencies as ASTIA, but do have some direct contracts of our own with technical groups. I speak now without complete familiarity, but, for example, we have contracts with some of the technical societies who perform abstracting services for us in the areas of cognizance of that particular technical society.

Mr. KARTH. To whom do you make available this information that is the result of the contacts that you have. There is no central agency, is there, that disseminates this information?

Mr. WYATT. The Armed Services Technical Information Agency is, to my knowledge, the most central agency within the total Government for this.

Mr. KARTH. Do they accumulate these translations from the Library of Congress and other agencies that do a certain amount of it?

Mr. WYATT. You are outside my area of particular technical competence, but it is my understanding they do, that they act as a focal point for receiving information from their own abstracting services, from services run by other agencies, such as NASA, and they are correlated together.

Mr. KARTH. The reason I ask, Mr. Chairman, is because if this is not being done, I think this may be a good area for some legislation.

I have the feeling we miss a great deal of valuable technical information; that we probably spend millions of dollars on research and development that otherwise could be made available for other purposes if we had some central point of collection and then dissemination of the information.

Mr. WYATT. This is correct, Mr. Karth. As we remarked at one of the earlier hearings, this is one of the major problems facing technology today.

Mr. BELL. Will the gentleman yield?

Mr. KARTH. Yes.

Mr. BELL. This is relative to a question I asked at an earlier hearing: What is NASA doing on its part when it gets information outside of ASTIA to give this information to ASTIA?

Mr. WYATT. Again, Mr. Bell, I cannot speak of this firsthand, but I believe that we make available publication of the abstracts or, at least, the lists of items that have been abstracted are made available to the general technical public.

Mr. BELL. As I understand it, today you have ASTIA, which is handled by the Air Force, you have DOD, and also the Department of Commerce, they have an organization, and NASA, I understand from your testimony, is now setting up additional ones. The more you set up the less centralized you become; is that not true?

Mr. WYATT. This is true in terms of centralization. On the other hand, the point I attempted to make in the earlier testimony is that the area of science and technology is so vast that there is question whether overcentralization might not be an evil.

We have certain areas in certain aspects of both science and technology that are of peculiar interest to us and we feel that it is advantageous, for our workings and for the workings of our contractors, for us to take a detailed look in those particular areas.

I am sure other agencies have similar detail problems.

Mr. Bell. Mr. Wyatt, we would all grant that. However, there is a certain broad area in which you and DOD and others are directly involved which would be a centralizing area of this kind. As Mr. Karth has said, it would be a tremendous saving, I would think.

Mr. Wyatt. We do get a tremendous value from the output of ASTIA itself. For example, at Huntsville, at the Marshall Space Flight Center, there is an ASTIA group being established that will jointly serve both NASA and the Army elements at the Redstone Arsenal in the Army programs down there.

That is one particular case where the ASTIA group is being established right on site, at the potential customer site, one might say.

Mr. Bell. I would like to agree with Mr. Karth's statement, that this is an area that may need investigating, looking to possible legislation.

The Chairman. I would like to ask Mr. Wyatt, would some sort of an interagency group to coordinate this be feasible, or should this perhaps be part of the responsibility of the new science group in the Office of the President?

Mr. Wyatt. I know that Dr. Wiesner's level is concerned with this. I do not know what specific recommendations they will make. I would not be surprised to see some recommendations from that group regarding how we can best utilize the work being done by the several agencies and how it can be jointly pooled to be made available to all.

Mr. Karth. One further question, if I may, Mr. Chairman.

The Chairman. Yes.

Mr. Karth. Dr. Wyatt, after you retrieve and translate those technical journals that might be of peculiar interest to NASA, do you then make the information available to the contractors?

Mr. Wyatt. It is made available to the technical public at large, yes, sir.

Mr. Daddario. Mr. Chairman?

Hasn't the National Science Foundation played an increasingly larger role in this field of translation in the last years, and haven't they been limited by the vastness of the program and the size of the job? They have taken it over the course of the years one bit at a time until, and to the point where, as of today that agency as well as others have done a great deal more in this field now than was the situation, let us say, 2 or 3 years ago?

Mr. Wyatt. I believe this to be so, Mr. Daddario, but I cannot speak with assurance. This is not an area that I have any deep understanding.

Mr. Daddario. But my point is that there is much more being done in this field by Government agencies than the Government is generally given credit for?

Mr. Wyatt. Yes, sir; I believe this to be the case.

Mr. Daddario. The field has enlarged, there are more translations, including Chinese and Russian documents; is that correct?

Mr. Wyatt. I believe this is correct, sir.

Mr. Daddario. And that there is also an improved method of dissemination, as I understand, not just to the contractors but also to engineers and technicians, throughout the country, and that this program does enlarge year after year, and that there is within the Government an attempt to tie together the product of this foreign research, foreign translation?

Mr. WYATT. That is correct, sir.

Mr. DADDARIO. And the Central Intelligence Agency also plays a great part in this role, naturally.

Mr. WYATT. Yes, sir.

The CHAIRMAN. Will you proceed, please.

Mr. SLOAN. One other product of putting together these overall system descriptions and functional diagrams will be that it allows all of the NASA integration groups to have another last chance at identifying and resolving any of the more subtle system incompatibilities, which just take a lot of time to look into and carefully engineer out; by making this system design information available to all program participants, we will let everyone on the project know what the other engineer has done in his own area of responsibility.

At the launch site, where the entire space vehicle is assembled for the first time, overall functional diagrams are invaluable in signal flow and functional troubleshooting.

The availability of such information can be the difference between efficient launch preparation, and an agonizing series of technical delays and holds.

The importance of the configuration control area cannot be overstressed. We must have rigid and absolute control over the exact design status and the drawings which document it. They must be available to the engineers and technicians who are preparing a vehicle for launch.

Unauthorized last minute "fixes" cannot be permitted in an operational flight program.

We must know that each change or modification has been properly reviewed for its effect, not only in the subsystem in which the change was made, but on the performance of the overall space vehicle system.

In the event of malfunction during flight, we must have an absolutely accurate record of the design of the flight equipments for rapid and accurate diagnosis of the problem.

These objectives are achieved through technical direction by NASA to its many contractors.

This technical direction takes place in the design reviews, the integration panels, and in almost continuous working engineering sessions. Our specifications and technical directives document the decisions made as the program progresses during the development phase.

It should be emphasized that the detailed technical direction for the manned space flight program is done by the National Aeronautics and Space Administration; that is, by a Government agency, and not by a "hired" technical manager.

We have the "in-house" capability to do this vital part of the program and are continuing to build up to an even higher level of capability.

Although we have hired contractors to produce our equipment, and to advise us and prepare studies for us, we have hired no one to manage our program.

System checkout: In another area, system checkout, we are taking significant steps to expedite our test programs, again, on an across-the-board basis. We are developing, for installation at Cape Canaveral, an integrated system checkout facility for the conduct of overall space vehicle system checkout, launch preparation, launch countdown, and launch.

This system checkout equipment will provide the information to the launch director necessary for him to certify the flight readiness of a space vehicle.

A launch decision is thus made, based not only on a series of separate stage tests, but also on the basis of overall tests which certify the overall performance of the entire system, working as a system.

In addition to these tests at the cape, there are a large number of checks and tests elsewhere. This overall test program generally consists of a series of tests at different levels of detail, with, at certain locations, the ability to step into further detail if equipment troubles seem to exist.

Therefore, by putting together a coordinated test program, and performing a careful study of the test equipment required at all stages of test, we can again conserve our resources and expedite our program.

We have test and checkout equipments required for original factory calibration, test, and acceptance of each stage at the contractor's plant. For propulsion stages, there are live static firing tests required before final delivery.

Upon receipt of stages at the launch site staging area, the integrity and status of the stage after transportation is verified.

Test facilities are required to accomplish this. In the vertical assembly building, described to you last week, the launch vehicle and spacecraft stages are assembled for the first time, and integrated testing is initiated.

First of all, the launch vehicle readiness as a multistage vehicle is verified, as is the spacecraft in a similar manner.

And finally, overall space vehicles system checkout is performed in preparation for the launch.

The integrated system checkout design philosophy takes into account the high degree of similarity among the different checkout equipments capable of performing the many necessary different levels of stage tests.

We will attempt to maximize the use of either common stage checkout equipment or design techniques, and in all cases establish common methods of test data acquisition and recording.

In the development of the system checkout facility at the cape, we again will maximize the use of already developed stage checkout equipment and probably be able to incorporate some of this into the integrated system checkout facilities.

We will apply similar design, data measurement, and data recording techniques throughout our checkout program to the maximum possible extent.

We will be thus able to perform repeatable tests during all phases of our test programs, and be able, for example, to quickly compare test results at the launch site with data obtained months previous, from a test performed at a contractor's plant thousands of miles away.

Because of this effort the manned space flight programs will achieve, we believe, more efficient and faster prelaunch tests. We expect to have a much greater degree of confidence that our space vehicle is in the maximum possible state of flight readiness prior to launch commitment.

The engineering resources available for application to this area of conserving financial resources are many. For example, we have the broad experience of the participating NASA field centers.

Integration experience at Marshall Space Flight Center goes back for many years. The earliest U.S. satellite was the product of a payload and booster vehicle integration effort of Dr. von Braun's group.

The manned spacecraft center was responsible for the integration of their Mercury capsule with their own Little Joe test booster, the Redstone booster produced by the Army, and the Atlas booster developed by the Air Force.

Checkout experience at Marshall includes current work on Saturn C–1 automatic computer controlled checkout equipment. A breadboard of this equipment is being currently installed at Huntsville.

We expect to gain considerable experience from this test program and apply much of it to the Saturn C–5, Apollo space vehicle program.

The Mercury group has considerable practical checkout experience gained from the very careful, generally manual, test and checkout work on the recent successful Mercury flights.

At the Office of Manned Space Flight, we are bringing to bear significant experience in the field of automatic checkout for electronic and vehicle weapon systems acquired on Defense Department development programs. We have also hired a capable and resourceful contractor to assist us in this program.

Because of the complexity of our program, we must utilize the experience and assistance from all possible sources. In particular, we will be able to make maximum use of the Department of Defense background through the newly established Air Force Office of Manned Space Flight, located in our own building.

As this liaison group expands its staff, we will have an organization parallel to our own to draw upon for help from appropriate Department of Defense space programs.

This will insure that their ballistic missile and manned aircraft experience will be factored into our program.

Our program effort will, in the integration area:

(1) Avoid duplication of costly design effort.

(2) Avoid costly redesign at the launch site.

(3) Avoid the need for costly last minute crash development programs.

In the checkout area, we will, with a coordinated central program:

(1) Maximize use of similar equipments.

(2) Minimize the launch facility test program.

(3) Minimize opportunity for human error.

This concludes my prepared statement.

I would be happy to answer any questions in the areas I have described.

The CHAIRMAN. Mr. Sloan, we read of Atlas successes and Atlas failures. Are all Atlases standardized in their construction now, or is each a separate vehicle with the generic term "Atlas" attached to it?

Mr. SLOAN. I am not sure I can speak with complete knowledge of the overall Atlas program.

The CHAIRMAN. I have named Atlas. You can apply my remarks to any rocket or missile.

Mr. SLOAN. During the development phase of the Atlas program I believe they started out with what was called the A–B–C series. Later the D and E, and I believe the F series Atlases have been produced.

I believe within one series the design is standardized. I believe there are changes between the D and E Atlases, let us say.

The CHAIRMAN. These are improvements over the past efforts.

Mr. SLOAN. Yes.

The CHAIRMAN. Is the F the one that we are using now?

Mr. WYATT. We are using in our program primarily the D version, sir.

The CHAIRMAN. Are all of the D's alike?

Mr. WYATT. I don't believe we can say they are all exactly alike.

Dr. Richard Morrison is here in the audience from our launch vehicle group that deals with the Atlas as used with the Agena and Centaur. He may be able to elaborate on this point.

Dr. MORRISON. In basic design, Mr. Chairman, they are the same. There will be minor changes depending upon their use, which comes down to the basic equipment that for all intents and purposes is the same in any one series of the vehicle.

The CHAIRMAN. Any questions?

Mr. KARTH. Mr. Chairman.

The CHAIRMAN. Mr. Karth.

Mr. KARTH. What happened to our checkout system on the recent Mariner flight?

Dr. MORRISON. The checkout system?

Mr. KARTH. Yes.

Something should have checked out. There was a lack of information fed into the computer system, as I understand it from reading the newspapers.

The thing that caused the failure was not the bird or guidance system, but the lack of feeding a hyphen into the mechanism of the computer—a $12 million hyphen.

Dr. MORRISON. This will be covered later, but what I would like to say on this one is that about 300 separate runs of the equations were made in the computer. The equations were checked out.

It was an error not to simulate rate beacon failure in the equation.

Mr. SLOAN. I believe it would be possible to say that the planned degree of automatic checkout, and the planned degree of program checkout on the manned space flight programs will take into account just such items, so we won't run into difficulties of the type we occasionally have experienced in the past.

I believe the Mariner checkout program is a combination of both manual and automatic methods of testing.

Dr. MORRISON. That is correct.

Mr. KARTH. Maybe, Mr. Chairman, for the benefit of the committee who have not been reading the New York Times, which is about the only place I saw a full and complete explanation of what happened, one of the gentlemen at the table would explain precisely what did happen?

Dr. MORRISON. Yes.

The Atlas guidance system consists of both radar and Doppler track. The autopilot which nominally programs, I should say programs, nominally, the trajectory of the vehicle, is altered in flight by command signals from the ground.

With no command signals from the ground you have a nominal trajectory which is usually not sufficiently accurate to guarantee a flight such as to Venus.

The corrections to the autopilot, which is on board, are applied by command signals from the ground, their signals being derived from both radar data and a modified coherent Doppler system.

The equations which govern the flight are in a computer, you monitor the flight, detect how far you are off from the desired precise trajectory, then shortly after sustainer flight, alone; this is where you drop the boosters, you command the correction into the very precise trajectory.

The information that you attain from the Doppler and the radar track on the vehicle is recorded through the entire flight.

The correction at 145 seconds is the first correction.

The tracking information received by the Burroughs computer facility operating in conjunction with the guidance system is compared to the desired trajectory and the precise version of the nominal trajectory is fed into the guidance system.

Nominally in a flight you do not plan on, but you expect, that you will at some time lose signal from the beacon on board the Atlas. This is for two reasons. One is the antenna patterns which will put you in a planning region——

Mr. DAVIS. What was that?

Dr. MORRISON. The antenna patterns.

Mr. DAVIS. Blind spot?

Dr. MORRISON. Yes.

Secondly, you do have the antenna radiating through the exhaust plume of the rocket which, at high altitudes billows to a large extent. This is highly ionized gas and can affect the antenna pattern and hence do not get beacon transmissions back to the ground.

So you have the provision in your equations that when such beacon signals are lost, or you lose lock on the beacon—I might take a little detail here—the signals are sent from the ground up to the vehicle, the vehicle in turn translates these, or sends them back as opposed to just having the beacon riding on board as a transmitter with no transmitter on the ground.

The standardization is on the ground, not in the vehicle iself.

Now, nominally what you would do is reject rate beacon information any time that you lose beacon lock, and resort to the pulse beacon, which gives information, though not quite as accurate as from this continuously operating beacon, but sufficiently accurate to guarantee the flight.

It is the computer that rejects it.

This rejection signal in the program for the trajectory was left out. So therefore through a flight region where you lose beacon lock, false information was fed to the computer and the vehicle did exactly what it should have done with the false information it received and not rejected, hence commanded hard left and nose down. The vehicle responded.

If the beacon had not lost lock and it had stayed in all of the time, the vehicle would have functioned very nominally.

Mr. DAVIS. Who is responsible for this?

Dr. MORRISON. It is the responsibility of the Office of Space Sciences, and particularly it would be the Office of Launch Vehicles.

The authority for carrying out the work is through the Air Force, which is our vehicle—I do not mean vehicle as a launch vehicle, but our vehicle by which we do handle the Atlas-Agena program, and they have the contract with the Space Technology Laboratories to provide these equations for the flights.

Mr. DOWNING. The equation to reject was not placed in the computer, is that basically what happened?

Dr. MORRISON. The term of the equation that would reject this information was not in the program.

Mr. WYATT. In perhaps less technical language, Mr. Downing, there is a term that should be fed to the computer that says ignore certain kinds of data.

Mr. DOWNING. I see.

Mr. WYATT. If you receive certain data, ignore it, and calculate around this data. This particular term was not present in the computer program and so it received data which was not good data and tried to make sense and tried to issue commands based on really nonexistent data and it did issue commands.

The CHAIRMAN. Who is responsible for leaving this out?

Mr. WYATT. Basically the guidance equations and trajectories are the responsibility of the Space Technology Laboratories.

Mr. DOWNING. This was a human error.

Mr. WYATT. It was a human error.

Mr. DOWNING. Somebody failed to put this in the machine?

Mr. WYATT. Is that correct?

Dr. MORRISON. Yes.

Mr. FULTON. Who checks the individual who is to put this term in the computer?

Dr. MORRISON. This would be the division of the Space Technology Lab that handles this directly.

Mr. FULTON. Does NASA check to see that the computers are correctly fed the equations? Doesn't any outside inspector check, or is it just up to the Space Technology Lab technician and if he does not do it nobody else knows about it?

Dr. MORRISON. This is a minute detail of the equations, which I agree should be checked. However, in good management practices, if we followed every detail to this point, we would have a tremendous staff.

Mr. FULTON. I might say to you, $12 to $14 million direct loss with overhead expenses would bring the loss up to $18 or $20 million, plus the time, plus the loss of prestige in the race with the Russians. It would seem to me to require a system of checking to see that the contractor programed correctly, because there is no hurry on doing the computer analysis and feeding it into the computers; you can do that any time.

Dr. MORRISON. This is true. I would like to point out there were 300 runs made of this equation. This is one of the checks that should have been made, which was in error. But many checks were made which would simulate failures of other parts of the system.

Mr. FULTON. But the check that was left out was the failure of the guidance system?

Dr. MORRISON. Yes, sir.

Mr. FULTON. That to me is a tremendous element.

Mr. KARTH. I am not sure I got the gentleman's question correctly. Maybe I misunderstood the answer. What did you say?

Mr. FULTON. The question was that the guidance system was not thoroughly checked through on the equations because a reject term was left out. This particular term was left out, but it doesn't tell us how many others might have been left out.

Mr. DAVIS. Will the gentleman yield?

Mr. FULTON. Yes.

Mr. DAVIS. May I suggest that was not a failure of the guidance system but was a failure to program a command to the guidance system.

Mr. FULTON. I agree mechanically there was no failure of the guidance system. It was the failure to feed into the computer a rejection term which the guidance system should have had.

Mr. DAVIS. Yes.

Mr. FULTON. My point is that we know of one term that was not fed in, but we do not know whether there were others not fed in, because this was the first one up that destroyed the vehicle.

Mr. WAGGONNER. Will the gentleman yield?

I share your concern there.

I would have to be reluctant to say we hire enough personnel to check every man we have got to do everything. That would mean, if we pursued that to an endless conclusion, we would have two people doing every job. We would have two administrators—two people on every job—a man checking every man.

We know the human is not without error.

I think if we check back on the Navy we would find people out there testing torpedoes who are still making mistakes and still have torpedoes sink at sea.

I share this concern but this is much like safety precautions for men that work with their hands.

I think it is a mistake they will try to correct in time to come. I imagine whoever made that mistake feels about as bad as some of us do. It is not something that we are going to stop by talking about it here.

We will make other mistakes, it may not be in one, but we will make others, that are obviously human errors. It is just the failing of the human being. I hate to see them happen but I do not know how to stop them.

The CHAIRMAN. I am sympathetic with the gentleman's position. We say that every time we have a failure we learn something. Now, we learned something here.

I hope it will not occur again. It is a pretty expensive lesson. Not only in money, but as Mr. Fulton has pointed out, the Nation's prestige and our own standing in the world at large, and that of the committee.

I can understand the intricacies of this, or I feel that I have vague knowledge of what you are talking about, but we certainly should be able to devise some system for checks that will not allow this type of error to creep in.

One of the excuses they gave, where you have so many Atlas failures, is they are all different.

Automobiles are all different too. Eventually the manufacturer works the bugs out and comes up with a pretty good motor.

I think that we have got to work the bugs out of these things. We have been at it now for sometime.

But this is the reason we are having these hearings, to point up some of these matters, and make sure that NASA is alert to these things and is conscious of them and is taking steps to correct them; taking steps as they become more sophisticated and will eliminate the duplications and unnecessary costs, because the program is costly enough without these things.

Mr. WYATT. Mr. Chairman, if I may, this is exactly the context in which we hoped that Mr. Sloan's remarks would be taken by the committee. There are things that can can be done, for these are tragic mistakes, failures, and when they occur which we do not propose to idly live by, we will make every effort to cure them.

Secondly, I would point out Mr. Sloan is describing an integration and checkout approach in the manned flight program upon which we have conditioned the whole success of that program.

You gentlemen, I believe, are familiar with the fact that the first Atlas that we fired in the Mercury program was somewhat over No. 100 in the Atlas series.

We are proposing in the development of the larger launch vehicles, starting with the Saturn C–1 and Advanced Saturn, to begin to perform operational missions using those vehicles with as little as perhaps 10 to 12 test firings, and one of the ways we think this can be done is by applying a more systematic integration and checkout technique from manufacturer to launch.

We feel it is not only desirable, it is imperative in terms of potential cost of the program if we went back to the system of firing a hundred of these very large vehicles before we could declare them to be operational.

We think it can be done, and think through the approaches of the sort Mr. Sloan discussed, we can achieve an operational capability of a high order of reliability with an unprecedented low development schedule.

The CHAIRMAN. Mr. Teague.

Mr. TEAGUE. Is there a financial loss to anyone except the Federal Government in a failure?

Mr. WYATT. No, sir. There are no penalty clauses of that type in the contracts.

The CHAIRMAN. Any other questions? Mr. Bell.

Mr. BELL. Mr. Chairman, this is a different subject.

I noticed in your remarks, Mr. Sloan, the last page referred to the Air Force manned space program as parallel to ours.

Is that parallel in every respect?

Mr. SLOAN. My remarks here had to do with General Ritland's office that has been set up, in fact, I think on the sixth floor of the same building in which the NASA Office of Manned Space Flight is located.

This is the liaison office established to promote closer technical interchange of information between related Air Force programs and NASA programs.

I think this staff will be organized parallel with our Office of Manned Space Flight organization so there will be an Air Force man concerned with integration and checkout and I can work with him to become informed about USAF techniques.

Mr. WYATT. I was about to say, we are not referring to a parallel Air Force manned space program, Mr. Bell.

General Ritland wears two hats. One is in the liaison function with NASA, and I believe he is also Deputy Commander for Manned Space Flight in the Air Force Command.

As such, they have their own programs in the Air Force, but he also serves, because of the very close technical correlation required, in this dual capacity as heading this liaison group to NASA.

The CHAIRMAN. That provides very good liaison.

Mr. WYATT. Yes, sir.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. The Air Force has been mentioned in connection with the Mariner Venus shot. Of course, the Air Force supplies the facilities.

There is no inference the Air Force was in any way responsible for this failure?

Mr. WYATT. No, sir. We are not pointing the finger at any element outside of NASA or even any particular elements inside of NASA at this point.

We are examining the whole system to find out how we can avoid, not only this particular failure, which obviously will be easy to correct in the future, but, as you suggest, the similar kind of things that did not happen this time but might happen some other time.

Mr. FULTON. Couldn't there be any automatic checkout equipment to eliminate such human failures?

Mr. SLOAN. My feeling is that a well-thought-out automatic checkout program, including equipment as well as the computer programs to be utilized both in the checkout equipment and in the operational hardware, would indeed avoid many problems of this nature.

We can repeat tests quickly and do it with very small expenditure of time and effort, if we have automatic facilities that we can turn on and operate, rather than set up expensive and time-consuming manual tests.

I believe this sort of thing would probably be picked up if one had an automated checkout system.

However, this has to be designed into the program at the very beginning. It is extremely difficult and extremely expensive to start 3 or 4 years after a program has been underway to put this back in.

It is usually not even possible.

Mr. FULTON. We have spoken of a $14 million hyphen as the cost to the Federal Government.

Actually, the feeding in of this term of rejection to the computer is not a minor matter, it is major in preparing your flight program; isn't that correct?

Mr. SLOAN. That is correct.

Mr. FULTON. At what level within the company was this error made; what type of individual made it?

Mr. SLOAN. I will have to refer to Dr. Morrison.

Dr. MORRISON. The error would be made by the individual that was making up the program. This would be a senior engineer or scientist. This was made by the individual that is making up the program.

Mr. FULTON. Whose responsibility is that and what type of individual is he? Is he a mathematician, technician, foreman, supervisor—so that we can see within the corporate structure that the proper care, management, and administration is being carried out?

Dr. MORRISON. I do not know the individual. I know the type of individual. This would undoubtedly be a man with a doctor's degree in mathematics, with considerable experience in celestial mechanics.

Mr. FULTON. I was at Cape Canaveral that night of the shot. I saw the fine shot that started. There was such a perfect start; then complete tragedy to everyone there.

You were in charge of the program and, of course, have outlined how we saved money by integrating the automatic checkout, watching the contractors, and launch pad procedures, and so on.

As you remember, President Kennedy, in May 1961, outlined the speedup of the program of the lunar flight. I agree with him. I think it was a fine decision.

Has anybody at NASA made an estimate of the cost of that speedup to be $7 billion additional expense because of the speedup? If so, who made the estimate and before what committee was it given?

Mr. WYATT. Mr. Fulton, this $7 billion question is incorrectly in context. Dr. Hugh Dryden testified before this committee last summer that the acceleration of the goal of landing men on the moon from sometime in the 1970's into this decade, would result in an increased expenditure in this decade of some $7 to $9 billion.

Mr. FULTON. But you state definitely there is no increase in total expenses, that anybody can say that, because of the decision, the moon program costs $7 billion more in expenses?

Mr. WYATT. Not totally; no, sir.

You see, regardless of when we accomplish the actual tasks, regardless of the target goal, the same technological tasks have to be performed in detail to get there before the end result, whether before or after 1970.

Mr. FULTON. This President's decision moves up the program.

Mr. WYATT. Yes; there is more in this decade. Of course, if we perform the mission before the end of the decade we will not have the expenses that otherwise we would have had in the decade of the 1970's.

Mr. FULTON. I think somebody in NASA better clear that up.

The CHAIRMAN. I might say there is a letter here from Mr. Wyatt, addressed to Mr. Hammill, as a result of these statements, which will be put in the record.

Mr. FULTON. May we finish on that?

In order that we have it directly of record, in your opinion has the speedup of the President's declaration of May 1961, cost any appreciable amount more to the space program simply because of the speedup?

What is your opinion?

Mr. WYATT. Our opinion, is, if anything, it probably will result in less cost in the final completion of the total task.

Mr. FULTON. So there is no loss of efficiency due to the speedup, nor is there a tendency to slight the programs and cause errors.

Mr. WYATT. No, sir, certainly not intentionally.

Mr. FULTON. The NASA programs are running at an orderly, efficient speed, with every care being taken for the expenditure of the taxpayer's money and every care being taken to obtain economies.

Mr. WYATT. We so believe.

Mr. DADDARIO. To which contractor do you refer, bottom of page 8, when you say we have also hired a capable and resourceful contractor to assist us in this program, Mr. Sloan?

Mr. SLOAN. I was referring to the General Electric Co.

Mr. DADDARIO. When you say you have hired a capable and resourceful contractor to assist you in checkout, is that the only contractor who will be involved, or does he sort of supervise other contractors involved in the whole checkout process?

Mr. SLOAN. General Electric now has a study contract where they are putting together recommended implementation plans. We expect they would indeed either put together or develop themselves the integrated system checkout equipment. We expect them to make maximum use of existing equipment developments and not necessarily produce all of the equipment themselves.

Mr. DADDARIO. They will not replace the contractor personnel?

Mr. SLOAN. No.

Mr. DADDARIO. Who participate in the checkout program itself?

Mr. SLOAN. No. I am talking about the development of equipment itself. General Electric's responsibility at Cape Canaveral in the checkout area would be of maintaining their own equipment which they put there.

Government employees would conduct the launch operation itself, or conduct it through the stage contractors, as the case may be.

Mr. DADDARIO. At this stage of the game I imagine right through the end of the program, the number of contractor personnel who still participate in the checkout would be larger than the number of NASA personnel?

Mr. SLOAN. I believe that would be true.

Mr. DADDARIO. There doesn't seem to be any possibility this will diminish so there will be cost saved at this end because, as I understand it, this is considered to be the most sensitive part of the whole operation?

Mr. SLOAN. We believe there will be fewer people required in gross numbers in the launch crew as a result of developing an automated system checkout facility.

I don't think we are in any position today to come up with comparative numbers.

Mr. DADDARIO. As I understand it, at Canaveral we have a checkout facility for Mercury, we have a checkout facility which is going to be constructed for Gemini, we also then will have a checkout system which will be included within the vertical $400 million building. All of these checkout systems will be separate and apart one from the other, is that correct?

Mr. SLOAN. The Mercury checkout system is primarily a manual one tailored to that particular capsule design. The Atlas checkout equipment that is used for the booster is a modification of the Air Force developed Atlas checkout equipment.

The Mercury checkout program is, again, tailored to the Titan booster and the Gemini capsule itself.

Mr. WYATT. The Gemini program, you mean.

Mr. SLOAN. Yes.

Our plans for the checkout equipment in the vertical assembly building, which will be pretty much the first general purpose launch facility we have put together, will be designed in such a way that we can utilize for the next generation of launch vehicles or spacecraft the same basic checkout equipment with possible changes in mating equipment between the standard checkout equipment and the space vehicle and changes in computer programs in our checkout equipment.

So we expect this facility to be with us for several years in the vertical assembly building.

We can use it for different stages.

The CHAIRMAN. Is that all?

Mr. DADDARIO. Just a couple questions.

The reason I am inquiring is because we do have a very costly part of the program in this area and we do have extensive checkout facilities.

I think it is important to understand it is contemplated they will be integrated over the course of time and finally put together, that when you have all of the equipment finally designed, it should result, should it not, in a diminution of the number of peole who will be involved?

Mr. SLOAN. It should indeed.

Mr. DADDARIO. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Davis.

Mr. DAVIS. I am not sure which witness should field this question particularly.

As I understand Dr. Morrison, he said in his judgment it was an error not to simulate the beacon failure before this last Venus shot.

If that be true, of course, there was another error of judgment other than the one on the part of the mathematician who programed the commands into the guidance system, is that not correct? There was an error in the man who set up the checkout system if he left out that particular checkout which was to simulate the beacon failure?

Mr. WYATT. Yes, sir; I think this is true.

Mr. DAVIS. Whose responsibility would that have been, or whose responsibility was that?

Mr. WYATT. This, I believe, was also the responsibility of the space technology laboratories.

I think we should point out, Mr. Davis, that as Dr. Morrison indicated, there were over 300 computer runs made. There are literally hundreds of things that might happen. While we do not excuse this error and cannot shrug it off, this happens to be one particular kind of a potential error that was not checked in the computer program to verify that the computer program was complete.

We cannot excuse it. It should have been checked, obviously.

As you indicate, there was a double error, the error of not having the term in, and secondly, not having picked that particular condition as a test check.

Mr. DAVIS. That is all.

Mr. FULTON. On that point: You have all the time in the world to run the computer checks, so why wouldn't it automatically be run with some sort of a check on the failure of the guidance system?

Mr. WYATT. I cannot say, Mr. Fulton.

This is one of the things we are looking into, as to what are the factors that govern this particular area.

Mr. FULTON. I would like to have on the record, on the management portion, how this occurred specifically.

I would like to have that put on the record, to see what the management failure was.

Is this same company going to handle the equipment for the next Mariner shot, and when is that shot?

Mr. WYATT. The next shot is scheduled in the August time period.

The STL is the contractor to the Air Force for the Atlas, which we procure from the Air Force.

Mr. FULTON. That seems to put the Air Force into this, but they are really not in the Mariner failure.

Mr. WYATT. We do not independently contract for the subsystems and integration of the Atlas. We buy the Atlas actually launched from the Air Force. I am not trying to blame the Air Force but pointing out if we chose we cannot change the contractual arrangements between the Air Force and its subsidiary contractors.

Mr. FULTON. Doesn't that cause NASA trouble on seeing that the whole programing equipment and everything that goes into it works out. It looks to me as if there is no overall responsibility of inspection and control to see that the proper procedures are followed.

That is what I have been complaining about on these programs.

Mr. WYATT. We are studying this, Mr. Fulton, to see if there is a modification in the contractual technical management arrangement that will improve these kinds of situations.

Mr. FULTON. How do you explain four out of five failures with Atlas-Agena at Canaveral when the record has been so much better elsewhere?

If I am a businessman, and I believe on the next five launches I will lose four tragically and a fifth one really not successful because of guidance, I may think that as a matter of probability chances of success are stacked against me.

I don't know what it is. Can you tell us what it is?

Mr. WYATT. No, sir, we cannot. We are studying this to ascertain for ourselves exactly what it is and what positive steps can be taken to overcome it.

Mr. FULTON. Can you explain the success of the other Atlas shots?

Mr. WYATT. No, sir, we cannot.

Mr. FULTON. That is all.

The CHAIRMAN. Mr. Bell.

Mr. BELL. Mr. Sloan, my questions go to page 3 of your statement relative to that centralized library.

I will ask you this direct question, inasmuch as Mr. Daddario brought this up.

Who would be a logical candidate to handle the centralization of this technical information?

Could that be the National Science Foundation?

Mr. SLOAN. The technical information which——

Mr. BELL. ASTIA for the civilian ends, in other words.

Mr. SLOAN. As far as the information we are putting together for the Apollo program, we are talking about here a detailed description of a particular program and those equipments associated with it, and we have decided we would not attempt to duplicate, for example, efforts of ASTIA or the NASA technical information groups to put together, let us say, general technological reports and general scientific information.

This is purely a program oriented for a description of what we are doing on the Apollo.

Mr. BELL. My question was in a broader scope.

Mr. SLOAN. I don't feel qualified to discuss the work being done in that other area. I do know I feel the Apollo program management people should have at their disposal all of the program information associated with our own designs.

I do not think we would want that in a generalized file.

The CHAIRMAN. I assume, Mr. Bell, you have in mind something like the medical library established out on the grounds of the NIH where the Army, Navy, the Air Force, Public Health Service, combine all of their familities and now call it the National Medical Library, not assigning it to anyone?

Mr. BELL. Yes, something similar to that.

The CHAIRMAN. This is a great step in getting away from parochialism. I think that is what you are striving at.

Mr. BELL. That is right.

The CHAIRMAN. That is what I would like to see. We don't want to force this on the scientists. May we go to your next witness—excuse me—Mr. Randall.

Mr. RANDALL. You said the Air Force and STL.

Mr. SLOAN. STL—Space Technology Laboratories.

Mr. RANDALL. You didn't mention any specific contractor did you?

Mr. SLOAN. They are contractors to the Air Force.

Mr. RANDALL. Thank you, sir.

We have some of the answers Mr. Fulton requested before these hearings are over.

Mr. SLOAN. Yes, sir; we hope so.

The CHAIRMAN. Your next witness, Mr. Wyatt.

Mr. WYATT. Mr. Chairman, we would like, at the pleasure of the committee, to have Mr. Gerald Truszynski, Deputy Director of the Office of Tracking and Data Acquisition, to describe some of the efforts being made to conserve the total national investment in the worldwide tracking data facilities required in this program.

STATEMENT OF GERALD M. TRUSZYNSKI, DEPUTY DIRECTOR, TRACKING AND DATA ACQUISITION

Mr. TRUSZYNSKI. Thank you, Mr. Chairman, and members of the committee, I would like this morning to give you some idea of how NASA, and particularly our Office, the Office of Tracking Data Acquisition, goes about assuring support in the area of data collection to all NASA space flight missions in as efficient and economical manner as possible. It was with this one main thought in mind that the Office was created in the November 1 reorganization of NASA.

The problem of providing tracking and data acquisition support to all NASA space flight missions in a timely and, particularly, an economic manner is highly complex when one considers the variety of

90751—62——8

missions which must be supported and their corresponding wide variation in trajectory characteristics and data requirements. To be effective, these requirements must be technically understood individually and at the same time examined in a totally across-the-board fashion. The job of tracking and data acquisition must be understood within the context of all NASA and other agency programs that derive support therefrom and within its limitations, scheduling problems, and the future capabilities that may be derived from augmentation and development improvements. The technical facilities and equipment utilized in tracking and data acquisition support are, by proper planning, usable for the support of many different flight projects. The value of combining all tracking and data acquisition functions in one office has been recognized by the National Aeronautics and Space Administration and the Office of Tracking and Data Acquisition has been created to so direct this technical area of effort that a maximum number of NASA space flight projects with their differing data requirements are supported with the minimum of new facilities and equipment.

By a continuous technical interchange and participation in program planning with the NASA program offices requiring support, the Office of Tracking and Data Acquisition is constantly attempting to effect overall economies in the following ways:

(*a*) Fit existing equipments to requirements.

(*b*) Reshape and alter mission orbits or trajectories to take advantage of existing ground stations.

(*c*) Recommend judicious alterations to technical requirements.

(*d*) Make minor and relatively inexpensive additions to existing equipment.

(*e*) Move existing equipment to new locations to meet requirements.

(*f*) Adapt equipment for purposes for which it was not originally intended or designed.

Only when these possibilities have been exhausted are new facilities planned and implemented.

In short, the Office of Tracking and Data Acquisition's job is to insure a maximum support to NASA programs and projects through the use of all suitable tracking and data facilities. These include those which NASA operates as well as those in operation by the Air Force, Navy, and Army and even some commercial and foreign-owned facilities.

Many examples are available of the savings derived from this judicious cross-use of facilities; several are listed as follows:

(*a*) For support of the NASA Tiros meteorological satellite program, a large high-gain receiving antenna facility was required on each coast of the United States. It was found that a high-gain receiving antenna developed by the Langley Research Center and installed at the NASA Wallops Island Station in support of the many probe and satellite research missions launched there possessed the proper technical characteristics to support Tiros. By installing the necessary Tiros read-out equipment at this site and by direct mission interscheduling, this facility was able to provide the required support. Similarly, negotiations carried out with the Navy Pacific Missile

Range allowed the use of a 60-foot receiving antenna on San Nicolas Island for the west coast requirement. Both of these facilities have been continuously supporting the Tiros program since 1960 in addition to their normal support to programs at the respective locations. Separate facilities of this type specifically for support of Tiros would have amounted to some $950,000 plus additional operating costs of some $75,000 per year.

(*b*) The highly elliptical satellite, Explorer X which ranged some 145,000 miles from the Earth, required a highly sensitive receiving antenna in order to obtain the information from apogee. By designing and installing a proper frequency feed compatible with the Explorer X on the deep space antenna at the JPL Goldstone facility, the required support was provided although the facility was extremely heavily involved with the Ranger lunar spacecraft tests. The alternative would have been an expensive, single-purpose facility built in Hawaii.

(*c*) The most outstanding example of NASA use of Department of Defense and other agency tracking and data acquisition capabilities is the cooperative establishment of the Mercury network of 16 stations, including 2 ships. Of the seven C-band radars used in this network, only one had to be purchased and installed by NASA to meet the initial three-orbit requirements; this was at Bermuda. One located at Woomera and owned by the Australian Government was utilized; the remaining five were existing Navy, Army, or Air Force instruments. These radars go about their business of support to other missions during a Mercury mission. Had we not been able to work out the complex technical and scheduling details of such an arrangement, the cost of similar installations would have increased the cost of the Mercury network by at least $9 to $10 million.

The original Mercury network was designed for maximum support to a three-orbit mission; a thorough analysis of the mission and a decrease of the data and communication requirements from the original 5 out of each 15 minutes that does not compromise safety requirements indicated that we can support the upcoming long-duration Mercury missions without requiring any new stations by relocating the two ship stations and by augmenting the command and communications capability at some of the remaining stations.

(*d*) There are certain events attendant to space mission execution that occur over ocean areas. These events require data to be obtained by rather expensively outfitted instrumentation ships. For example, lunar and planetary missions must begin their final flight to the mission objective from locations that vary with time and are determined by the positional relations existing between the Earth and the Moon or planet. These locations are for the most part over water. During the last few months we have been engaged in a very extensive study with the Department of Defense to examine both NASA and DOD requirements for instrumentation ship support. These requirements were grouped by geographical area and time of need. After determining the total joint requirements, these were fitted to existing and firmly funded ships. The resulting deficiencies appear to indicate that only one or perhaps two additional ships will be needed in the immediate future to support the programs of both agencies. The results of this cooperative study have indicated that the large scale originally anticipated on the basis of individual NASA and DOD requirements will not be needed. Again, by technically examining tracking and data acquisition equipment capability versus requirements and judiciously altering each, such joint efforts have proven technically sound and operationally possible with the obvious attendant and important savings to the Government.

It should be pointed out that an overall saving to the Government is also obtained by a considerable support to Department of Defense flight missions by NASA tracking and data acquisition facilities. All requests for support of DOD projects that do not affect NASA's nonmilitary role have been honored due to the ability to fit NASA noncritical (politically) stations to Department of Defense mission requirements with minor and comparatively inexpensive alterations to these stations. For example, a new feed was installed on the NASA Woomera Deep Space Net Station to support Blue Scout launched probes from the Pacific Missile Range.

NASA has prepared operations plans for support by NASA facilities on 13 Department of Defense missions and plans to support future missions include at least 6 more payloads. Cost savings in actual dollars is difficult to compute but such savings are possible due to NASA and the Department of Defene ability to fit mission requirements to existing equipment and into the existing heavy NASA schedules at a minimum cost for modifications and new equipment for augmentation.

The costs of operating the tracking and data acquisition networks are under constant review. The ground communications network that ties in the oversea stations, the NASA centers, the national ranges, and the major cities of the United States is required for data transmission, command and control, and administrative traffic. It represents a considerable recurring cost every year. Much effort goes into the dual jobs of increasing performance and reducing cost. Since December 1961, we have been able to reduce costs here by at least $750,000 per year without any reduction in service.

The basic solutions we are applying are the use of leased commercial facilities instead of toll systems, the use of the GSA communication network to supplement our own, the constant review of message traffic and of message routing to insure economical operations, and the gradual development of a complete and flexible communication net for the entire agency. For example, the Langley Research Center has been in operation for many years; as it has expanded and its communications needs grow, its toll call bills reached some $25,000 per month. Last month we completed the last tie-ins of the Langley Research Center with the NASA-approved GSA leased-line system. The monthly bills are now only $14,000 and the service has been expanded. To give you an example, a direct 3-minute toll call from the Langley Research Center to Richmond costs $0.45. If we route that call over the leased facilities to Washington and then back to Richmond, it will only cost the Government $0.30. These leased lines are incorporated under a new tariff system called Telpak that allows low cost, on a flat-rate basis, for bulk communications.

The NASA tracking and data acquisition stations are usually operated by contractor personnel both in the United States and overseas. We reduce expenses at these stations whenever possible without affecting the missions themselves. For example, in every country we make maximum use of local personnel and competence. Not only is this politically appropriate, but is far cheaper than using only U.S. contractor personnel.

In keeping with the across-the-board program, jobs of the Office of Tracking and Data Acquisition, an area that has produced and will produce many more cost savings is that of ground equipment standardization. The temptation to develop an independent and wholly new support system for each flight project is continuously repressed. As an example, the 85-foot-diameter data acquisition antenna at Fairbanks was the first of its kind; the design, engineering, fabrication, and erection cost some $910,000. By assuring that the initial design provides the capability for multiproject support and thereby procuring duplicates of this system for installation at Rosman, N.C., in Alaska, and in Canada, we can bring the cost down to almost $760,000 each. Similarly, the 85-foot-deep space antenna stations are designed to be identical. Thus, not only are initial costs reduced, but the whole process of logistics and maintenance is simplified. By a continual review of data requirements and the support planning to meet these requirements in the light of existing facilities, the Office of Tracking and Data Acquisition can perform very effective functions in assuring a properly economical approach to the overall job of obtaining the critical information from space flight programs.

Mr. TEAGUE (presiding). Any questions, Mr. Hechler?

Mr. HECHLER. Mr. Truszynski, where will you locate your three new deep space flight tracking stations for which funds are being authorized by Congress this year?

Mr. TRUSZYNSKI. The additions to the deep flight space network will be located at corresponding longitudes to the existing stations. The critical technical parameter involved here is locating them at a similar longitudinal part of the world.

Mr. HECHLER. I was trying to pin you down to the specific locations. When will you make a decision as to where those will be located?

Mr. TRUSZYNSKI. We have a site survey team that will depart for Australia within 2 weeks to find a suitable location for additional facilities there.

We are also investigating the possibility of locating the one corresponding to South Africa and we are investigating Italy at the moment and it may be located there.

Mr. HECHLER. From a cost-saving standpoint, either in this area or some other area, I wonder if you have thought about the possibility of utilizing the facility which the Navy Department is abandoning at Sugar Grove, W. Va., the "big ear," as a possible space-tracking site in the future?

Mr. TRUSZYNSKI. Yes. NASA is interested in investigating the possibility of use of the Sugar Grove site for tracking and data acquisition facilities for our programs. We are in process of getting together with the agencies involved that control the entire West Virginia area from the standpoint of its so-called radio quiet to determine whether or not the facilities of our type can, in fact, be located there with minimum or no interference to the existing National Science Foundation antenna at Green Bank.

If this does turn out to be a possibility, we certainly are interested in utilizing whatever site preparation has been carried out at the Sugar Grove site.

Mr. HECHLER. I want to ask you about electronic computers. We had some testimony during the NASA authorization bill that a vast amount of money was spent by NASA in the rental of electronic computers, and the question was raised whether you wouldn't save a great deal through the outright purchase of such computers because they are used over a rather lengthy period and the rental costs are high.

At that time, as I recall, you said you were making a study to ascertain just what policy to follow.

I wonder what progress that study has made?

Mr. WYATT. I perhaps can address myself to this.

We are continuing the study. I do not know what the definitive results are. Basically, we are guided in this area, as was pointed out in the testimony, by the Bureau of the Budget circular which sets certain permissive standards, in the sense that we do not have to use them but cannot get by with less standards, on the rent or break-even point in terms of the utilization of the particular computer, its amortization life, and when it becomes economical, in terms of its projected utility, to buy rather than rent. I cannot say specifically in terms of any specific computer what decisions have been reached there at this point.

Mr. HECHLER. That is all.

Mr. WYATT. We do this year round, I might point out.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON. The radio telescope at Jodrell Bank, England, is still in operation. They are doing basic research on radio stars. Would it be possible to use the West Virginia facility of the Navy for that purpose?

Mr. TRUSZYNSKI. The West Virginia facility plan did include investigations of radio astronomy.

I can only say if it had been successful in being carried out to completion, it could have indulged in radio astronomy, yes.

Mr. FULTON. Are we contracting for any time at Jodrell Bank through any U.S. agencies in radio astronomy?

The question being, Could we as well do radio astronomy research programs on our own U.S. facilities were we to complete the Navy installation through NASA?

Mr. WYATT. May I answer this, Mr. Fulton?

I don't believe we are in position technically to address ourselves to the question of how much radio astronomy time is being purchased by Government agencies.

NASA is not engaged in a radio astronomy program as such.

We would utilize Jodrell Bank as it is as a tracking station.

Mr. FULTON. NASA has the basic research function as well as the development function. Why shouldn't we have a NASA radio astronomy basic research program in order to explore the extremes of outer space beyond the optical telescope instrument limitations?

Mr. WYATT. I cannot say that in the future for certain we will not engage in such type of astronomical observations. However, as a matter of policy up to this point we have interpreted our charter for the exploration of space to rather limit ourselves to the actual space flight articles.

We have felt that the existing scientific competence in the areas of both visual and radio astronomy is sufficient without NASA stepping in and augmenting that program for its own part.

Mr. FULTON. That is for navigation, within our planetary system.

But if there is anything I ever added to this Government's space program, it was that in the 1958 act for establishment of NASA, every time whoever gave us the original proofs said "research and development" I added the two words, "and exploration."

So that the intent of that act was that NASA should have the program of "exploring the universe," not the planetary system alone.

I find nothing in the act which limits you to either engineering and navigation or the planetary system.

I would like to have in the record what the estimates would be that a program would cost of radio astronomy. I understand our West Virginia facility would be superior, because of our radar bowl being of a later generation than the Jodrell Bank telescope at the University of Manchester in England, where, incidentally, I worked for a day to learn about its operation some years ago.

With the chairman's permission could we have that put in the record?

Mr. TEAGUE. If it is available.

(Information requested not available.)

Mr. FULTON. One other point is this:

We have the tracking installation at Woomera. We likewise have the installation in South Africa. We have Goldstone installation in California. NASA is planning two other tracking stations; one, I understand you say, will be in Italy; the other one I had understood could probably be in the Northern Hemisphere in the Pacific Ocean area, particularly in the Western Pacific.

Could you comment on construction of that particular station that is being proposed in the current budget?

Mr. TRUSZYNSKI. The facility in the current budget in the Far East is not for support of the deep space programs but is for support of the scientific satellite programs, the orbiting geophysical observatory.

Mr. FULTON. So your deep space program facility that you propose would be somewhere in Australia, in the Southern Hemisphere?

Mr. TRUSZYNSKI. Yes.

Mr. FULTON. And the Northern Hemisphere would be around the vicinity of the longitude of Italy?

Mr. TRUSZYNSKI. No. The one in the Northern Hemisphere, which might go in Italy, is the deep space facility.

Mr. FULTON. That is what I say.

Mr. TRUSZYNSKI. In addition to that one, there is a Far East facility currently in the budget that is required for the support of the satellite programs.

Mr. FULTON. My point on the Far East station is this: I would strongly recommend that it be placed on U.S. territory or on the U.S. Trust Territories of the Pacific and that we check to see which of the U.S. Trust Territories, the far spread Pacific Islands, can be used for this purpose.

The United States has this U.N. trusteeship under the United Nations Security Council with the right to fortify.

Under these circumstances I hope that will be seriously considered, because we need industry, or jobs, for these people in order to let them develop.

I would recommend that to you strongly.

Mr. TEAGUE. Any other questions?

I believe we have one other witness.

Mr. RANDALL. One question: This one in the Far East, why would not any of the islands off of Alaska be suitable for that?

I am concerned about the employment of these natives not so much as the security of the tracking station itself.

Mr. FULTON. I am, too.

That is my point.

Mr. RANDALL. I am sure that is what you meant.

Mr. TRUSZYNSKI. The missions that this facility will support are low inclination orbital vehicles. This means we have to have a facility that is relatively near the equator.

Mr. RANDALL. What about Hawaii?

Mr. TRUSZYNSKI. The longitudinal position of Hawaii is not proper.

Facilities that will support these programs require to be farther apart than the United States and Hawaii for maximum coverage.

The general Far East area is technically suitable.

Mr. FULTON. Is there any planning being done on a joint launch site which the United States will participate in and erect under U.N. auspices in India that will be open to all nations for launch purposes?

The idea being the United States supplies most of the money through the U.S. Treasury and that India does the housekeeping and running the station.

Is that now being programed by NASA?

Mr. WYATT. Our next witness, Dr. John Clark, I think, may be able to address himself to that.

Mr. FULTON. That is all.

Mr. TEAGUE. Mr. Wyatt, let us have Mr. Clark.

Thank you, sir.

Mr. TRUSZYNSKI. Thank you, Mr. Chairman.

Mr. CLARK. In view of the time, I will try to be brief.

Mr. TEAGUE. Thank you, sir.

STATEMENT OF DR. JOHN F. CLARK, ASSOCIATE DIRECTOR AND CHIEF SCIENTIST, OFFICE OF SPACE SCIENCES

Dr. CLARK. Mr. Chairman and members of the committee, the economical management of our major national programs is a matter of vital concern to every America. One of the reasons this country has been able to lead the world in progress has been that its people have learned to do things more efficiently than other peoples. Efficient operation not only makes the product competitive buut also frees time to undertake other tasks. Thus, the subject of this hearing is a very basic one.

When the United States first began its space program, in the wake of Soviet successes, we set out to lead the world in space exploration. It was not so much a question of how to do it for the least possible cost, as it was how to do it at all.

In the opinion of many, we have accomplished our first objective of establishing the preeminence of the United States in space exploration. We clearly lead the Soviets in the space sciences; we have been unique in applying our basic scientific and technological knowledge to the practical benefit of mankind with our meteorological, communications, and navigational satellites; and we have drawn abreast of the Soviets in developing a capability for manned space exploration.

This rapid progress was not made with a disregard for economy, however. As large as the NASA budget has become, the various projects within the total program have individually been forced to seek more and more economical modes of operation in order to live within their budgetary constraints. Rising costs have intensified our search for better ways to do the job. Nevertheless, space exploration is an expensive undertaking and deserves ever-increasing attention in the area of efficiency and economy.

What then are the secret ingredients of efficiency and economy? They are many, but the first is good management at all levels. Good management encompasses the following interrelated characteristics:

1. Good organization and personnel.
2. Sound and timely decisions.
3. Minimum duplication of effort.
4. Proper delegations of functional authority.
5. Close monitoring of organizational performance.
6. Dependable communications and information.

Good administrative and engineering management sets the tone of an organization and program. It makes it possible for good people to do a competent job. The Office of Space Sciences and the Centers which serve its program have and are continuing to strengthen their management.

Steps which have been taken include streamlining our own internal management and insisting on the same from our contractors.

In critical areas we have increased our staff to improve our ability to monitor our contractors. This has included an increased use of NASA personnel in residence at our contractors' plants.

As a basic policy, NASA has insisted on a strong in-house technical capability in both engineering and science in order to insure competent decisions and technical direction.

The standard by which we would wish to be judged is the success of our programs. To be fully successful, any individual project should be completed on time, for a reasonable cost, and with good mission performance.

The propect should look as good or better at completion as when it was a gleam in a visionary eye. This is a very tough order in the research and development business. We are striving hard to measure up to these performance criteria.

I would like to turn now to some specific approaches which we take in the interest of economy. This discussion will be more meaningful if I first summarize the manner in which the Office of Space Sciences spreads its research and development money.

In fiscal year 1962, the fund allocations were approximately as follows. They are listed in order of descending magnitude so that the first areas mentioned would normally be the most profitable areas in which to seek economies. Procurement of launch vehicles larger than sounding rockets is listed as a separate item.

R. & D. programs

	Millions
1. Launch vehicle procurement (including reimbursable items from other offices and agencies)	139.2
2. Lunar and planetary programs	118.4
3. Launch vehicle development	81.1
4. Scientific satellites	77.3
5. Research grants and contracts	13.0
6. Sounding rockets	9.8
7. Biosciences	4.7
Total	443.5

It is clear that our largest expenditures are for launch vehicle procurement and development. Early in its history, NASA joined with the DOD in adopting a limited stable of launch vehicles for joint utilization in a move toward economy and reliability. Despite this sound step, we have been plagued this past year by failures of the more advanced launch vehicles in this stable.

Although such vehicle failures almost invariably provide engineering data which tend to improve future vehicle reliability, nonetheless, these failures do result in loss of not only the vehicles but also the spacecraft which they carry.

The Atlas Agena has been our poorest performer. Out of four lunar probes and one planetary probe launched with this vehicle, there have been four failures; two attributable to the Atlas system and two to the Agena. We simply cannot conduct a successful or economical space program without higher vehicle reliability.

Hence, the NASA is actively supporting and participating in a strong effort by the USAF, through whom we procure Atlas-Agenas, to improve their reliability.

This effort involves the development and use of a standardized Agena D, which will not only be more reliable than the Agena B, but will cost about $450,000 less per vehicle. In addition, the Atlas is being standardized as a space booster for increased reliability.

All Agena D's are not at the present time identical. There are always certain mission specifics for which the vehicle has in the past been modified, and a program is now well underway to provide a completely standardized vehicle which can be provided to all users.

Procurement contracts will have incentive provisions which will both reward superior performance and penalize low reliability and cost overruns. Fixed price contracts are a distinct future possibility. Sound engineering and strict quality control will be keys to success.

In an effort to capitalize on the outstanding performance of our Thor Delta—10 successes out of 11—NASA is programing heavier usage of the vehicle.

The NASA solid propellent Scout has been developed to provide a lower cost—$1 million—easily launched vehicle. Strict standardization has been enforced on both these vehicles.

Other steps include a rigorous new reliability and quality control program which has been recently instituted by NASA for all equipment.

In addition, steps are being taken to improve factory checkout and ground support equipment to reduce "turn around" time and improve pad utilization, with attendant reductions in launching costs.

These lessons, some learned the hard way, are now being injected into the Centaur program.

One week ago Saturday, Congressmen Karth and Fulton, of this committee, joined a NASA group in observing an 8-minute full-duration run of the Pratt & Whitney A–3 engine for Centaur and Saturn.

This engine is rapidly becoming the most tested of all rocket engines prior to flight use. We hope that this attention to quality will give us a successful Centaur program.

In the lunar and planetary program, we are faced with not only getting more reliable launch vehicles, but also developing a series of complicated spacecraft to accomplish very difficult missions.

Since knowledge in technology is accumulative, our approach has been to program relatively long usage of the spacecraft, such as the Ranger series. When it becomes necessary to step up to the next generation of spacecraft, we attempt to carry over the technology which has been developed in the past series.

It has even been possible to utilize lunar spacecraft technology in our planetary spacecraft designs—that is, attitude control, auxiliary power, midcourse maneuver, and so forth.

In addition, we subject the spacecraft to a maximum amount of testing on the ground prior to flight. It is virtually impossible to do too much ground testing in the course of a spacecraft development.

A further step to improve reliability has been to contract with independent companies to review our spacecraft designs for ways and means to improve them. This has been done on both the Ranger and Mariner programs.

It has been this rigorous test philosophy which has resulted in such a successful earth satellite program. Satellite failures before several months of good data have been obtained are virtually unknown.

One highly successful approach has been to insist on qualification of scientific instruments in sounding rockets prior to flight in satellites.

As a result, our instruments almost always work. Improvement in satellite and instrument design has enabled us to carry a great many instruments in each satellite, thus getting a maximum of scientific information on each flight. This country excels in the development of reliable miniaturized instruments.

A very significant economy has been incorporated into spacecraft design through the use of standardized subassemblies and configurations in both electronic and structural elements.

For example, essentially custom built telemetry encoders can be provided for specific spacecraft needs using appropriately interconnected subassemblies such as oscillators, gating circuits, etc. This technique permits minimizing design effort, lower costs due to quantity production of the subassemblies, and fewer difficulties in qualifying spacecraft since most of the critical circuitry has already been qualified.

Similar examples would be the modularized tape recorder, structure and solar arrays prepared for S–52 (UK No. 2). It is estimated that the annual savings realized in fiscal year 1962 were approximately $800,000.

Over a year ago, we began the development of observatory type satellites. These satellites are designed to carry up to 50 experiments with ready interchangeability, and operating with common power, communications, and data recovery systems. Simultaneous gathering of so many types of data will greatly enhance the data utility.

Although such satellite development is initially expensive, their utilization over many years as "standardized" spacecraft will reduce the cost of obtaining equivalent data with a multiplicity of smaller satellites.

A not-so-obvious economy is the care we take in screening and selecting our scientific experiments to get the maximum return from each flight. An extensive system of working scientific subcommittees is utilized to guide us in this process. The university scientists participate in these evaluations.

In addition, the participation of foreign countries in our programs has increased the scientific output and, in some cases, has brought in foreign funds.

As new information is gathered about the space environment, it is fed into the design of our new spacecraft to improve reliability and life. For example, radiation damage to solar cells and circuitry is determined and protection devised. Destabilizing effects of the upper atmosphere, solar pressure, and the earth's magnetic field are also determined.

The space sciences program also represents an economy in our effort to place men on the moon. Knowledge about hazardous solar radiations and conditions on the lunar surface will do much to insure a successful culmination of this important undertaking. Design provision for these environmental conditions can be made at an economical point in the program if the data are obtained in time.

I would like to conclude with a brief commentary on the responsibility of industry to effect economy in the space program.

As never before, we are asking for low cost and high reliability from low volume production. Although our machines are among the most complex man has ever built, we must get high reliability very early in a flight series.

Industry must seek new techniques and procedures to accomplish this.

We are encouraging and helping industry to accomplish just this. As we succeed, the know-how and craftsmanship becomes a boon to not only the space program, but to all industrial enterprises and their consumers.

Mr. Teague. Mrs. Weis, do you have a question?

Mrs. Weis. No.

Mr. Teague. Mr. Downing.

Mr. Downing. One question, Mr. Chairman.

Getting back to the failures, have you analyzed them as to human error and as to mechanical error, and what is the percentage?

Dr. Clark. This is a difficult question to answer for the following reason—I would like first to return to the comments made by one of the previous witnesses and set the record straight on the question of the failure of the Mariner I.

If we would let any one subcontractor or contractor or one element of the system be responsible both for carrying out their necessary function in the flight operation and checking to see that it had been carried out, then this would be a pretty important management error indeed.

Reference was made to the responsibility within the total system of STL in the programing of a computer. The program in this computer had been very similar for at least the previous two Ranger shots and had a similar loss of lock occurred similar problems would have occurred in the other flights.

A comment was made that STL is responsible for the checks that are then made. This is not true, at least, not wholly true. Responsibility for this rests with a committee at the Cape which includes responsible representatives of all participants and agrees upon a checklist to meet the requirements of everyone.

Now, one of the checks in this list was a simulation of total failure of this particular beacon and under this mode of operation responsibility was transferred, that is, I mean to say, in the computer, the program automatically switched to relying on data from the less accurate pulse beacon, as it should.

Everyone involved in this program simply did not extend their imagination to the point where the peculiar type of failure which occurred was envisioned, and the fact is that this was not quite so horrendous as this may seem discussing it here in the much more accurate light of hindsight.

Mr. FULTON. $14 million worth.

Dr. CLARK. Yes, sir, $14 million—it would be very difficult to estimate the number of thousands of individual steps which do have to be foreseen and which have been foreseen in addition to this one step which was not, and the question, therefore, as to assigning responsibility, the question as to a quick answer as to whether this was human failure, I don't think I can give you a direct yes or no answer to this sort of a question, except insofar as it is a human failure whenever a human being fails to have a sufficiently broad imagination to encompass all of the conditions under which he must instruct computers to carry out this type of complex technological job.

Going over the Ranger failures, the first failure was a component failure——

Mr. FULTON. The date?

Dr. CLARK. This was August 23, 1961, Ranger 1. This was a component failure, switch failure.

Mr. DOWNING. You mean mechanical?

Dr. CLARK. Yes.

Ranger 2, again, was a component failure, failure of a gyro.

Mr. DOWNING. Date?

Dr. CLARK. November 18, 1961, Ranger 2.

Ranger 3, January 26, 1962, was a component failure in the airborne guidance system.

Ranger No. 4, April 23, 1962, was a component failure in the spacecraft. That was not a vehicle failure. This was the occasion in which the vehicle was so accurate that the spacecraft did indeed impact the Moon, despite the failure of the computer to command midcourse guidance correction.

Mr. TEAGUE. Mr. Corman?

Mr. CORMAN. No questions.

Mr. TEAGUE. Mr. Randall?

Mr. RANDALL. No.

Mr. Teague. Mr. Hechler.

Mr. Hechler. No questions, Mr. Chairman.

Mr. Teague. Mr. Fulton.

Mr. Fulton. The problem comes on management and whether divided management is satisfactory. It should be satisfactory, but I must say to you that on your three out of four Ranger failures, and the fifth one, the Mariner, one failure, that it does look as if the incidence of failures is high when the management is divided between NASA and the Air Force, let's face it.

But when Air Force has the responsibility alone, there seems to be a higher incidence of success.

Not putting the blame any place, because these things are not to me research and development failures, they are technical failures of component equipment that is manufactured. These are reliability failures.

The question comes, shouldn't we change it and make a recommendation on this committee so that when the customer, NASA, has a certain program requirement, that then NASA has the responsibility all the way through, or some agent on its behalf, to do the inspection, checkout, fitting together the programs.

Under those circumstances then we would not have you come here and say "Well, after all, Air Force contracts for the launch and equipment and components, and this was unfortunate but this was a subcontractor under Air Force and there is no blame on Air Force."

That doesn't solve the problem. We get to the point where you people, of course, don't want to put it in the lap of the Air Force, I compliment you for that, but there is something wrong. I have asked would complete automatic checkout equipment do it. Possibly that is right.

Before we get to that—the comment has been made it is too late in this program.

Dr. Clark. May I comment?

Mr. Fulton. It concerns me. I will go to the next Mariner flight.

Actually we were out there watching the last Mariner shot. When we came back into the NASA Mariner headquarters and when they destructed that vehicle it was like an avalanche hitting a Swiss village. You see it is more than just "we are sorry."

Dr. Clark. Mr. Fulton, may I comment on the use of automatic checkout equipment in connection with this Mariner failure?

As we have seen, one has to instruct a piece of automatic checkout equipment what we wish it to check out automatically, and in the case of this particular failure there is no more reason to believe we would have foreseen this particular mode of failure with the checkout, as was the case, or perhaps we should say was not the case, with the manual checkout.

Use of any automated equipment does always bring in the possibility of failure in the automated equipment. Not speaking against the use of such automated checkout equipment, but I think we are all very much aware of the fact that although man is fallible he does have a degree of intelligence not yet possessed by any machine.

So we have been careful about excessive automation.

Mr. Fulton. I had a letter from a man in California, small manufacturer, with a bitter complaint on paying his taxes, and then having the Mariner I shot failure.

He says that the reliability of the components and equipment is not up to the standards that NASA should require.

The other point I make of this particular Mariner I failure to me is that was the equivalent of leaving the coffee pot on the safety valve. It wasn't expected that it would be necessary so that was a good place to put the coffee pot, and they put it on the safety valve.

Dr. CLARK. I would like to go on record as supporting completely your concern. This is not a laughing matter. It is not a trivial matter.

Mr. FULTON. It is a tragedy to me.

Dr. CLARK. It is well over $10 million. It is a national tragedy both in terms of time and in terms of prestige. You express this very well.

Mr. FULTON. The real tragedy is that the optimum time for Russia to make her Venus launch comes just before the period of 26 days that it takes us to get our second Mariner flight ready.

Dr. CLARK. I would also like the record to show that the insertion of the Air Force into this testimony is not in any way indicative of sharing responsibility for this failure. We have an agreement with the Air Force with respect to the Agena B program, both Atlas and Thor Agena, which specifically sets forth responsibility for the technical direction of the program with the NASA and responsibility for technical support with the U.S. Air Force.

Our people, specifically our agency, the Marshall Space Flight Center, to carry out this responsibility for NASA, has adequate authority to obtain all the information as to all the tests from the beginning of manufacture through the flight.

Any responsibility for any failure of any component, or any program, any plan of operation, any aspect of flight, is properly the responsibility of the NASA.

Mr. FULTON. Then why are these failures, when you and the Air Force try to work together? Why?

Dr. CLARK. I don't think, Mr. Fulton, that even five flights is enough of a statistical sample to say with any assurance that we have only 20 percent of success in the next flights.

I am sure you have seen, as I have, numerous occasions where you flip a coin a half dozen times and it comes up all heads or all tails.

Mr. FULTON. Yes, but the trouble with the position of NASA is that these are not research and development failures, these are reliability failures of component parts.

Dr. CLARK. Yes, sir; in part.

Mr. FULTON. Likewise they are failures of checkout and inspection. They are failures of the merchantability and the quality control by the subcontractors that are having the responsibility for particular system units.

It gets hard to go back to the American people and say four out of five of these have been failures, two Atlases and two Agenas failures, and a fifth one a vehicle failure, payload failure.

I look at these failures that run $12, $14, $16 million, as bigger in amount. They have expended scientific talent, they have lost our position in the race with Russia, they have hurt the American prestige on science and research, and they have in them a factor of at least 50 to 60 percent of overhead and indirect costs.

So each of these failures to me is a failure of $18 to $20 million. If you multiply that by 5, failures total somewhere between $80 to $100 million of the taxpayers' money, and not research and development failures. If it is research, fine, but it is the bolt breaking on the hatch door when they close it on Glenn, and he is ready for the flight. Secondly, a transformer fails within the last hour of the last countdown in that flight, thirdly, the power goes out in Bermuda at the tracking station, and that is the most important station, it is going to determine whether to inject Glenn into orbit, and fourth, there was an oxygen valve that stuck because of maybe faulty injection of liquid oxygen into the vehicle, also a transponder failure. Well, when I know of errors like that occurring within the last hour of countdown before we launch a U.S. man on his first orbit, a fine person like Colonel Glenn, honestly, it is tragedy. It isn't science and research. It is more than human failure. It is failing to live up to standards that are absolutely required in this particular type of space industry.

I hope you will set the standards and I hope you will set up an independent inspector general responsible only to the Administrator of NASA, as it has been done in the AID, the U.S. foreign aid program. Likewise, to his credit, Secretary of Agriculture Freeman has just set up such an inspection agency to check agriculture.

Mr. HECHLER (presiding). Dr. Clark, on the 2d of July this committee made a report on the Centaur development program and in that report they asked for a report from NASA on the future of NASA.

Dr. CLARK. Yes, sir.

Mr. HECHLER. And the NASA report is, I believe, due this week. I wondered if you could advise the committee as to whether the report will be forthcoming?

Dr. CLARK. Probably of the order of 10 days.

Mr. HECHLER. Thank you.

Dr. CLARK. It is in preliminary draft now with a good deal of coordination yet to be accomplished.

Mr. HECHLER. Thank you.

Mr. RANDALL. These four failures that you enumerated, Ranger 1, 2, 3, and 4, is there someplace in the record, or have you prepared a memo on those?

I would like for myself to know. I am concerned with these failures. We should be learning something. What are we doing about them? Specifically what have you done to follow up on them?

Dr. CLARK. I can state for you right now what we have done, if you want me to, very briefly.

Mr. RANDALL. Don't make it too long. Our time is gone.

Dr. CLARK. I think about 30 seconds. First of these was a switch which failed under high temperature environment in which it had never before failed. The switch was redesigned to provide for higher temperature capability, requalified at higher temperatures and a backup circuit was provided.

No. 2, this was a failure of a roll gyro which failed immediately after or at the time of launch at the time.

Marshall Space Flight Center had already recommended equipment additions which would insure a monitoring of operations of all of these three gyros down to the moment of lift-off, which was not available by the date of that flight. This equipment was subsequently incorporated in the Atlas ground equipment and no further problems of this sort have been noted or are expected in this regard.

In Ranger 3, this was the situation in which there was a failure in either the pulse beacon or its decoder or in the associated wiring. This was again a system which had not failed previously in many flights of the Atlas.

Even more intensive quality assurance procedures were initiated as a result of this failure and again no further, or no other, failures were detected of anything like this nature, besides this one particular failure.

In the case of Ranger 4, this was the spacecraft failure of the clock timer which had never failed during any of the ground tests or environmental tests. Precautionary measures have been taken just in case by providing a backup clock so as to have a second parallel function.

Mr. RANDALL. That has been done.

Dr. CLARK. Yes, and it will be incorporated in future Ranger spacecraft.

Needless to say, the recent Mariner failure——

Mr. RANDALL. That would be Mariner I.

Dr. CLARK. Yes. This failure was a failure to forsee and provide in a computer for a specific failure mode, which is now being provided for in Ranger II.

The failure mode is getting into a blind spot in the range rate beacon antenna pattern so as to have temporary noise reception as opposed to valid signal.

Mr. FULTON. That occurs in every flight?

Dr. CLARK. This can occur in any flight. It did not occur in Ranger 3 or 4.

Mr. FULTON. It is a possibility in every flight.

Dr. CLARK. It is a possibility, yes, sir.

Mr. FULTON. Thank you.

Mr. HECHLER. Are there any further questions?

If not, I want to thank you, Dr. Clark, and the other witnesses this morning, for your very helpful testimony.

The committee stands adjourned.

(Whereupon, at 12:20 p.m. the hearing was adjourned.)

90751—62——9

WAYS AND MEANS OF EFFECTING ECONOMIES IN THE NATIONAL SPACE PROGRAM

THURSDAY, AUGUST 16, 1962

House of Representatives,
Committee on Science and Astronautics,
Washington, D.C.

The committee met at 10 a.m., Hon. George P. Miller (chairman) presiding.

The Chairman. The committee will be in order.

This morning the full committee resumes its hearings on ways and means of effecting economies in the national space program. As most of you know, the gentlemen who are here to testify today were scheduled to appear before the committee a couple of weeks ago. Unfortunately, we received notice at the last moment that the House was to convene earlier than had been anticipated on that particular morning; therefore, it was necessary to reschedule these witnesses. Again, I should like to apologize to them for any inconvenience that the change of schedule may have caused.

We are certainly pleased to have with us again this morning Dr. Chandler Ross of the Aerojet-General Corp., and Mr. George Trimble, vice president of the Martin Co.

As we have said before, the national space effort involves a considerable investment of American scientific talent and money. There appears to be a general acceptance on the part of the American people that the investment is a wise one. Yet, it is important that we constantly review and reevaluate our programs in order to effect savings of the taxpayers' money whenever and wherever possible. There is no question in my mind that more economical methods and techniques can be introduced into the Nation's space program from time to time. The purpose of our meeting with these representatives of industry is to solicit their views and ideas in this regard.

I think the happenings of the last 2 or 3 days demonstrate that it is highly essential that we get on with the job. Personally, I am not panicked by what has been accomplished by the Soviets. I feel that, although theirs was a great, a spectacular feat, we could also send a vehicle into orbit and keep it there for 3 days, or 4 days, or 15 days with the equipment now available.

I don't know whether we could send up the facilities needed to keep a man alive that long, but we are striving toward that goal and we will get there. I don't think that their recent accomplishment indicates that the Russians have made any great breakthrough. I believe that they are using the tools that they already had.

It is my sincere wish, and I know I speak for all of us, that within the not-too-distant future we can come up with boosters that will be superior to theirs.

Of course, I know you realize as I do that in order to get men to the Moon, and get on with this job, it is going to require boosters much larger than any that have been used to date, either by the Soviets or in our programs; larger by two or three orders of magnitude than what anyone now has. This is the thing we are striving for, and I'm sure will be successful.

Now I want to welcome our first witness this morning.

Dr. Ross, I believe you are to lead off.

STATEMENT OF CHANDLER C. ROSS, VICE PRESIDENT OF ENGINEERING, AEROJET-GENERAL CORP.; ACCOMPANIED BY ROBERT C. TRUAX, DIRECTOR OF ADVANCED DEVELOPMENT, LIQUID ROCKET PLANT, SACRAMENTO, CALIF.

Mr. Ross. Thank you, Mr. Chairman.

My name is Chandler C. Ross. I am vice president of engineering of Aerojet-General Corp., a subsidiary of the General Tire & Rubber Co. Accompanying me is Mr. Robert C. Truax, who is director of advanced development at our liquid rocket plant at Sacramento, Calif.

We appreciate the opportunity to present our views to this committee on the exploration of ideas to introduce cost savings into our country's space program. Realizing the importance and timeliness of the subject, we sincerely hope our contribution will be useful.

My field and that of our company is principally propulsion, and our comments are most pertinent in this area. In space vehicles, the influence of the propulsion means on the system itself causes us to study and evaluate entire systems in order that we may remain abreast of the overall field and be in a position to anticipate propulsion trends.

For this reason we have considerable general knowledge in the "Earth-to-orbit" systems and, in addition, we have conducted complete stage programs such as Ablestar. The close relationship of the stage itself on means of propulsion necessitates participation of the propulsion supplier in practically all of the major areas which are cost influencing in the space programs. Another area in which our company participates heavily is facility design. Our architect-engineer division, Aetron, located in Covina, Calif., has participated in the design of installations at practically all of the major missile and space test centers.

First, we propose to review our thoughts on some of the basic economic principles related to costs of placing material into orbit, examine some limitations dictated by nature on the use of our current propulsion devices, and then present the status of two studies on rocket-powered devices which we believe can contribute to reduced overall costs in the future.

Directing our attention to costs, or more generally the economics of orbital flight, it is safe to say that we are dealing with an extremely complex problem. Since the scope of the U.S. effort itself is increasing at a rapid pace, many of the major economic considerations cannot be effective on today's scale of operations but must be planned to enter the program at some future date.

Such a situation increases the number of variables in cost studies, and one must be certain that the phasing of corrective action or new innovations is timely. Another general constraint further complicating the problem is a requirement that certain missions be accomplished within a time schedule such that some particular cost-saving innovations cannot be introduced because of the time limitations. It must be recognized that when this situation exists there has been a known tradeoff of dollars for time. Further general effects include that of learning through repetitive operation, the effects of increased reliability through concurrent efforts, and the introduction of new inventions.

The cost effectiveness figure of merit for boost systems is dollars per pound of payload in orbit. By the techniques of operational analysis, both current and cumulative values of this parameter can be estimated at various points during the projected useful life of a hypothetical boost system for a specific mission or range of missions.

The elements making up this cost parameter can be categorized in several ways. It should be remembered, however, that costs are of two types: nonrecurring and recurring, with the latter having a fixed expenditure rate portion and a variable expenditure rate portion.

Facilities, research, and development costs are examples of nonrecurring costs which are amortized in some fashion. Fabrication, checkout, launch, and operational support activity costs make up the bulk of the recurring category. Both categories are influenced by many variables, some of which are established by mission requirements (payload weights, launch schedules, etc.) and others determined from the characteristics of the boost system under study.

The values and nature of these variables for different system concepts may drastically change the relative values of the elements of cost within a single subsystem, as well as greatly influence costs in other areas through the complex interactions within the total system.

Today we are placing in excess of 40,000 pounds of payload per year into orbit at an average of over 1,000 pounds per launch. The current projected growth in space operations will lead to increases of orders of magnitude in the values of these parameters in the very near future. These effects alone will cause a drastic redistribution of the elements of cost as well as reduce the cost per pound of payload in orbit.

What may be the major element of cost under today's scale of operation may become a minor element in the very near future, and vice versa. In order to obtain the greatest cost effectiveness from development, it is necessary to define and undertake those developments which will satisfy the economic situation that is expected at development completion.

Before looking at some specific design studies, I would like to conclude my remarks on the general economics by saying that the greatest cost savings will be effected in future programs that it is incumbent upon NASA, the services, and industry to do the following:

1. Examine proposed programs critically in their makeup of costs in such a manner that development effort is expended in the areas of greatest payoff.
2. Critically examine the time sequencing of cost-saving innovations to be certain that their effectiveness is assured within the proposed use time.
3. Minimize, if possible, programs which trade heavily on dollars for time.

As a general comment, I would like to add that current programs represent a learning period and a period of gearing up for a tremendous scope of operations. We should expect this phase to be costly and, from an overall standpoint, it is our opinion that an excellent job has been done. The future will see the true payoff in cost savings.

Turning now to specific studies, Aerojet has investigated two areas of recoverable rocket boosters for large payloads. Both studies conclude that, for very large cumulative payloads in orbit, recovery systems will be effective cost-saving features.

The first system studied is a multistage unmanned version where weight and performance are not critical and the second is a manned version wherein performance and weight are of major importance.

It is interesting to note that two entirely different design concepts are represented. The previous discussion has been aimed at establishing criteria to measure the cost savings of such innovations. The review of these studies is an attempt to present the salient design features and recovery techniques. A tacit assumption in both studies is that the payload delivered to orbit will increase with time and that the rate of delivery will be of sufficient magnitude to warrant the effort to develop devices of this type.

The incremental savings estimated and the development time scale suggested are believed to be in the proper order of magnitude, assuming final technical verification and successful development.

We do not feel qualified to recommend the phase-in time at this point in our studies because it will be extremely sensitive to the overall space program.

THE ARGUMENT FOR LARGE, UNMANNED, RECOVERABLE BOOSTERS

The unmanned version, called the Sea Dragon, was studied at Aerojet under the direction of Robert C. Truax. Figure 1 illustrates the general features, and the following comments on the design are pertinent. These studies are now partially funded by NASA. The system promises substantial cost savings that are based upon three rocket booster objectives:

1. Make the booster as large as practicable.
2. Demand simplicity and ruggedness in the booster design and operation.
3. Recover and reuse the booster.

Presently projected boosters are land launched and are based on the largest liquid rocket engines available, yet, they cannot lift a million pounds of payload. They are also relatively fragile, complex, multiple engined, have complex pumping systems and, above all, they are not reusable. They require large land launch sites, expensive launch support installations, and are outgrowing surface transportation capabilities so that it may be necessary to virtually build them on or near their launch pads.

Multiple weekly launches of such vehicles are only feasible with a large land-launch installation and the attendant high costs. Similar land-launched boosters several times larger in size do not presently appear to be realistic for sustained operation.

Such size limitations need not be correspondingly critical, however, if the booster is launched in a free-floating attitude from the open sea. Sea-launch boosters can be towed empty and afloat with none of the size limits of land movements. In fact, if the sea-launched booster is treated as a ship, its size can approach that of a medium-sized ocean vessel and lift payloads well in excess of a million pounds.

The construction and assembly of the large sea-launched booster in ship-type dry docks simplifies its later movement by water and could use available fabrication facilities.

There is sound basis to expect that construction costs per pound decrease with increase of size. Large sizes would present development problems if current test installation methods are used. Testing in the open sea resolves most of these problems. The safety of sea isolation is expensive to duplicate elsewhere.

Sea operations of a very large booster that uses supporting vessels for tankers and towing will not differ radically from commonplace commercial and naval sea operations. The launch can be accomplished near existing missile ranges to fully utilize available tracking capabilities. In some cases, isolation of the launch far out at sea may be desired, particularly where nuclear-powered upper stages are being tested.

Where large-sized rockets are preferred, their operation from the sea appears to be the most logical technique to overcome size-associated problems. The sea-support costs are only a fraction of the land-installation costs. The flexibility of the operation and the safety afforded cannot be equaled on land.

Once the present size-limiting conditions are resolved by using sea-launch techniques, the practicality of large-sized space boosters will be more fully recognized and the economies that result will be realized.

A two-stage boost vehicle that uses single engines for each stage appears to be practicable. The use of pressure-fed tanks will drastically simplify the engine and its plumbing. It will also simplify the development work required.

Attendant with the pressure-fed system is the requirement for heavier tanks; however, increased size of even pump-fed boosters requires heavier tanks. The application of properly selected pressurizing techniques, attention to vehicle-tank-engine integrated design, and the exploitation of vehicle size can result in an ultrasimple booster with few moving parts. It will be rugged when pressurized; it will exceed ship strengths for open-sea towing. The size and simple component design will permit access to all elements; in most cases a man can pass through the piping system.

The simplicity and ruggedness has a very strong effect on improved reliability, which is a very important factor in reducing overall costs. The probable range of reliability in an operating system can show more than double the costs for the poor reliability case. Demands for high order of reliability, aside from the cost aspects, is implicit for manned flight which is expected to be the general case for boosters we are here considering.

The complex booster will inherently require more development time and cost to equal the reliability of the simple booster, and in some cases the complex design may never approach the simple design reliability. Aside from the cost argument, the need for highly reliable manned boosters alone would fully support the serious development of the most simple booster design possible.

Large size and simplicity of design are indeed true complements in space booster systems, and the sea-launched booster ideally exploits the best features of both elements.

Cost reduction achieved by recovering the booster stages, refurbishing, and relaunching can reduce costs by as much as 10 times providing the recovery system is highly reliable and requires little or no payload weight penalty.

The booster is sufficiently rugged and simple that it requires little or no refurbishment other than inspection to confirm its suitability for relaunch, and finally that the recovery operation is simple and inexpensive. Present-day boosters were not designed for recovery and could not meet these requirements, nor does it appear likely that the 1960–70 boosters will be suitable.

There are many recovery techniques, most of which compromise one or more of the above conditions. Of these techniques, the most promising is that of passive water recovery wherein a properly designed empty booster stage free-falls into the water and floats awaiting towing to the refurbishment location. The inherent features of the previously described large pressure-fed simple booster require very little special design features to become a suitable passive recovery vehicle. Furthermore, the developmental time and cost are minor considerations because the recovery system would be developed concurrent with the open sea development of the boost vehicle.

Large size, simplicity in design, and recovery have a high degree of compatibility and can result in a low-operating-cost booster, providing complete design integration of vehicle, tankage, and engines is maintained toward these cost objectives. Sea launch and recovery are the closing links to a successful booster suitable for the transportation needs of the 1970's.

THE ARGUMENT FOR MANNED, SINGLE-STAGE-TO-ORBIT BOOSTERS

The second system, a manned version called Astroplane, has been funded by Aerojet and studied under the direction of Dr. John C. Moise. Cost savings are proposed on the following basis:

1. Relative insensitivity to all parameters except system performance;
2. The use of engines presently under developments;
3. Undamaged recovery at the launch site;
4. Simplified operation through use of a single stage; and
5. A very long useful life system.

Astroplane is a liquid oxygen-liquid hydrogen rocket powered, single-stage-to-orbit, recoverable boost system utilizing vertical takeoff and horizontal landing.

For the configuration studied, the gross takeoff weight is about 10 million pounds, the landing weight about 550,000 pounds, and the payload about 550,000 pounds.

Sufficient lift is generated by the aerodynamic tankage configuration to provide reentry, glide flight-path control, landing capability, and aerodynamic stability. A typical configuration is shown in figure 2.

Aerodynamic stability is achieved by locating the engines well ahead of the aerodynamic center of the swept fuel tanks. The tankage arrangement utilized in Astroplane also provides for structural efficiency as well as aerodynamic lift for the following reasons:

1. The major percentage of the takeoff weight is liquid oxygen, which is carried immediately in front of, and closely coupled to, the engines. A relatively short load path through the liquid oxygen tank supports the payload;

2. The low density of hydrogen makes possible the "swept wing" fuel tank arrangement without introducing severe bending moments;

3. All tankage is a combination of cylindrical, spherical, conical, and ellipsoidal elements resulting in high structural efficiency;

4. Landing loads are carried through a short distance to the thrust takeout structure; and

5. Landing weights of about 550,000 pounds are within current runway capability.

The CHAIRMAN. What does a modern jet weigh?

Mr. ROSS. About half of that, I would say.

An analysis of payload composition indicates that at least 75 percent of the payload will be propellant (oxygen and hydrogen for chemical or hydrogen for nuclear rockets).

Astroplane takes advantage of this dual use to eliminate outage and trapped propellant loss by transferring residual propellant to the payload propellant prior to payload transfer. Reliability of redundant systems can also be improved by use of payload propellant as reserve propellant in the case of less efficient operation.

Considerable light can be shed upon launch economies by comparing these diverse features existing in the Astroplane concept and the Sea Dragon concept. The Sea Dragon concept, which very closely approaches some of the current nonrecoverable booster concepts insofar as structural design is concerned, can be considered as minimizing the special additional development costs for incorporating a recovery system.

In the Sea Dragon concept, the first stage booster is allowed to impact the water at its terminal velocity of about 600 feet per second. By virtue of aerodynamic stability, this system strikes the water nose first in a section which has been properly designed for a high velocity impact, and the structural aspects to permit this are an inherent part of the design, particularly the use of a pressurized tank.

It is noted that engine development for both stages is required, while the Astroplane concept, on the other hand, uses M–1 engines which are already under development by NASA. Astroplane is an aerodynamic vehicle which glides into a landing in an airplane-like manner. Consistent with this aerodynamic landing, then, are the multitude of problems and costs associated with a very high performance airplane-like configuration.

Clearly the structure has been compromised to provide an aerodynamic configuration, and there will be development costs associated with this compromise.

Precise estimates of development costs are difficult because of technological uncertainties, but have been estimated for purposes of developing figure 3.

An important consideration in the economics of these booster systems are the variable costs, or those costs which recur every time a launch is made. The most significant parameters in this consideration are the logistics and the actual launch function itself.

While the launch operations would differ between the vehicles, the most dominant variation is in the concepts for reuse; that is, the logistics of returning the launch vehicle to the launch site and preparing it for its next flight.

The Sea Dragon concept economizes in the logistic resupply through the use of the ocean as the transport medium. The vehicle, having impacted into the ocean, is towed to a seacoast or sea-based launch site, from where it can then be readily prepared for its next launch. The Astroplane concept, on the other hand, relies upon recovery at the launch site to minimize the reuse cost. The booster, having been placed into orbit, is allowed to remain in orbit until its mission is accomplished there and then returned to the ground at or near the point of launch. The recovery being in an airplane-like attitude, there is considered to be very little destruction or depreciation of the vehicle in this process.

This permits a very minimum of refurbishment cost and allows the variable costs to approach that of the resupply of the propellants and the range operation.

An additional and very important factor not covered in the discussion of fixed or variable costs is the question of manned versus unmanned operation of the system. The Sea Dragon concept employs an unmanned booster, while the Astroplane concept makes use of a pilot in the vehicle.

Considerations of the man center around two conflicting considerations. The first is the greater ease and lower cost of developing a system without the man on board, and this then is contrasted with the ability for decisionmaking and a greater reliability possible with the man in the system.

Consistent with other low development costs incorporated into the Sea Dragon, the absence of the man completes the story of a low cost, recoverable operation, while the insertion of the man into the Astroplane system completes the story for a higher development cost vehicle but one which incorporates greater versatility and reliability by virtue of the man's presence.

To complete the consideration of the economics of launch, it is necessary to consider the efficiency of various concepts in terms of pounds placed in orbit as a function of the booster gross weight. As before, the Sea Dragon and the Astroplane concepts represent extremes in considering this problem, and as such bracket these considerations.

The Sea Dragon, which makes economies in terms of simplified vehicle design, compensates for the associated reduction in structural efficiency through the use of two stages for launch to orbit. This results in a payload-to-gross-weight ratio of 4.5 percent. The Astroplane, on the other hand, being a single-stage-to-orbit vehicle, requires great sophistication of structure in order to achieve a 5.5 percent payload-to-gross-weight ratio in orbit.

The relative economies realized by using the Astroplane or the Sea Dragon, as compared with the nonrecoverable Saturn C–5, are shown in figure 3. For this purpose, the Saturn C–5 is not charged with development and facilities costs, whereas these fixed costs are amortized into the Astroplane and Sea Dragon costs.

These funds have been committed and they will be spent, but the fixed costs in connection with the Astroplane and the Sea Dragon are amortized over the payloads indicated.

Referring to this figure it is interesting to note the total amounts of payload which must be launched into orbit in order to economically justify either program. The lower limits of the possible delivery cost curves show costs below those of the Saturn C–5 for total payloads above about 12 million pounds for the Astroplane and 34 million pounds for the Sea Dragon.

The upper limit values show uniformly a payload value of about 70 million pounds at a delivered payload cost of $100 per pound. Since these data are based upon an operational life of about 9 years, even the pessimistic break-even point of 70 million pounds represents an average yearly rate of less than 8 million pounds minimum required. With even these most conservative values, then, an operational time period extending into the latter 1970's may see the average payload requirements well exceeding the 8 million pound figure.

Scheduling this back in time through a booster development program, then, we can see implicit justification for the analytical and experimental programs now underway, and an urgency for considerable extension of, and additions to, this work.

The conclusions and recommendations as a result of these studies are summarized as follows:

In each case the incremental cost saving is of sufficient magnitude to warrant continued feasibility studies of these systems. It is not possible to make a selection at this time because major features in each concept require demonstrated feasibility.

In the case of the Sea Dragon, work is underway to demonstrate water recovery in larger scale; however, active work on extremely large-scale engines is not contemplated, to our knowledge, and should be pursued.

Feasibility of the Astroplane is contingent on further detailed studies approaching an actual design phase to substantiate the structural-to-gross-weight ratio.

Although a considerable effort has gone into structural design, it has been insufficient to consider all regimes of flight in the atmosphere.

Thank you.

(The charts referred to follow:)

FIGURE 1.—Sea Dragon Concept

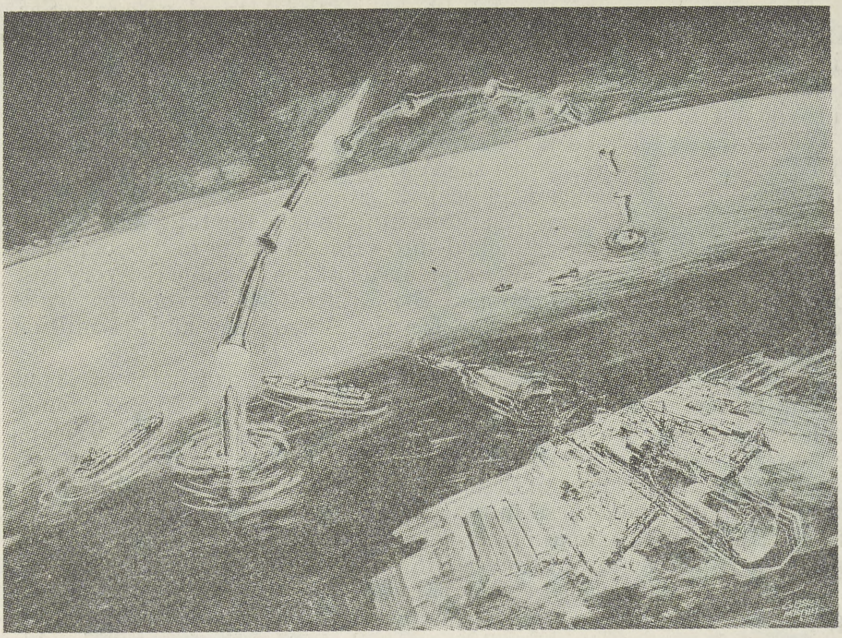


FIGURE 2.—Astroplane Concept

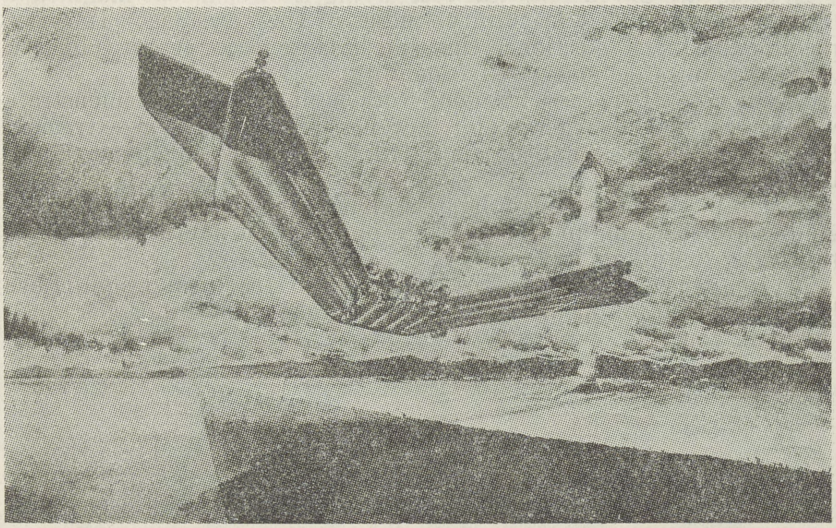
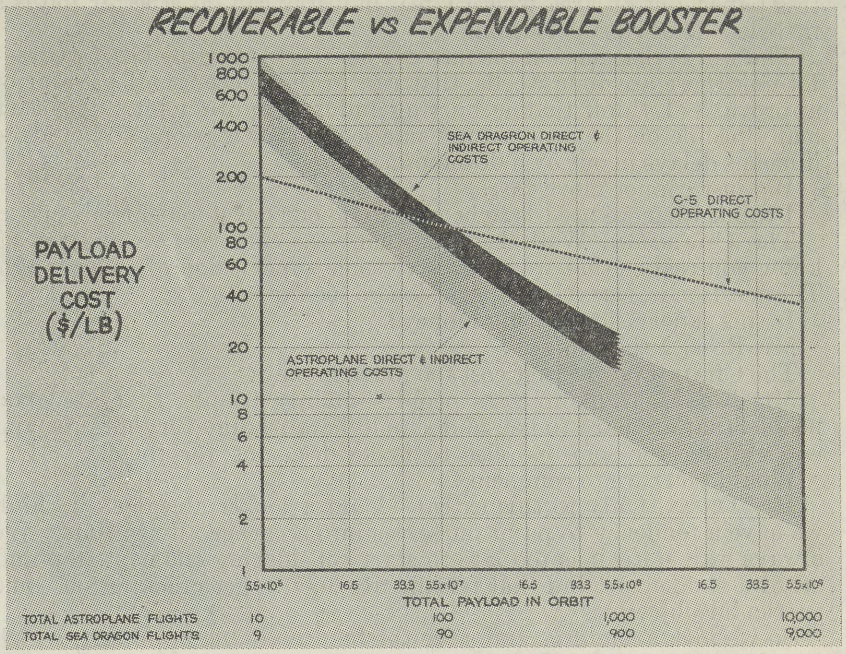


FIGURE 3



The CHAIRMAN. Doctor, your presentation is most interesting, but it involves things that are some time in the future.

I know that we all appreciate and understand that we some day will have to come to some type of recoverable vehicle. We just cannot afford to spend the money that we put out on these vehicles for one-shot affairs.

You said on page 4 of your statement, that the major element of cost under today's scale of operation may become a minor element in the near future.

The major element of cost today is the booster vehicle itself.

If we could recover this vehicle it would become a minor or recurring cost.

Mr. ROSS. Mr. Chairman, I think, if you will closely examine the total cost of programs today, that probably the actual vehicle costs today are not the significant cost, but the costs of the launch operations, supporting operations, and the development costs, and in large scale operation these are likely to reverse, where the costs of the booster itself becomes the important factor.

The CHAIRMAN. I was struck by the fact that you feel, apparently, as you say on page 5, that you think an excellent job has been done in this field, but the future will see true payoff in cost savings.

Now, the thing that I am primarily concerned with at the present time is, Do you think there is any immediate place that you could suggest where money could be saved in today's operations, or do you think that NASA and DOD programs are going forward efficiently and that there is no great waste of money taking place in present operations?

Mr. Ross. I think my comment might be aside from the subject of this paper, but an area where I feel industry can do a better job is a little less detailed supervision.

The words that have crept into our contracts over the last 5 years—I think there are four words, that run to the effect "shall have prior approval"—I think that is hurting industry quite a bit. It means many people on the contractor's side looking over peoples' shoulders, it means delays in our own development time.

We just cannot move fast.

I think what we need is to be able to do our development job faster.

The Chairman. Well, I think that is a constructive answer. I know you realize that we must have some supervision of this though. The question is, Does this supervision go too far?

Is this supervision costing money?

Mr. Ross. I think it is.

The Chairman. Does it cost too much money?

Mr. Ross. I think it costs people—mainly people, that are good people, that are hard to get, and should be working every minute, and not waiting for someone else to make decisions for them.

Would you care to comment?

Mr. Truax. Only to this extent—I am a looker-aheader. I think we have a tendency to paint ourselves into a corner all the time. We always wait until it is too late to start considering the next step and all of a sudden we find that terrific urgency to get cracking on some particular objective.

So we look around us and seize the best available approach, which may be a long way from being the best possible approach, and this is because we have failed to anticipate what we are going to do far enough in advance.

So, having boxed ourselves in, we find that the approach is very expensive; we always underestimate it in the first place, so as we go into the later phases of the program we find an even greater requirement for money, and this tends to sop up all the available funds so that we now have no funds available for exploring what we should be doing after this particular phase, so that when this is over and we find the U.S.S.R. has done another spectacular and we have to kick off a new major program, we are back in the same box we started from.

I think someone has got to show enough, let's say, administrative courage, even in the face of very demanding need programs, to reserve an adequate amount for the exploration of better ways of doing it.

Right now, as an example, the contracts that have been let by Marshall Space Flights Center for looking beyond the Saturn C–5, so-called possible Nova study contracts—I might say they are called post-Nova because originally the Nova was firm and it seems to be getting less firm at the moment—these contracts are for $75,000 apiece.

This is absolutely peanuts compared with the billions that we devote to a going program. I think something has to be done to upset this ratio.

There would be, I think, great wisdom in devoting perhaps $20 to $30 million a year to the most promising three or four concepts for downstream applications and hold hard and fast to that allocation of funds, keep them from being sopped up by the pressure of our present financial needs.

Only in that way are we going to save large amounts of money, but we are not going to save in today's program.

We will save it in tomorrow's program, the one beyond, say, the first landing of men on the Moon.

We have done this all along. We take the most immediate objective.

I sat on the original Man in Space Committee, as it was called in the days before the NASA. The big question there was: Should we shoot for one man or two men? There was great pressure to beat the Russians to it. We settled for a one-man configuration, whereas with a change in vehicles, one which actually was under development, the Atlas-Agena, we could have put two men up in the original approach, but it would have taken a little longer.

As it has turned out, we did not get the first man into space, so that the propaganda value of it had largely vanished, and in retrospect, had we done it the other way and gone off with two men, gone for the big step, looked a little further downstream, we could have done many things—such as rendezvous, getting out of the capsule—things which would give us a longer range capability and would contribute more to a really full capability in space.

I think this is something we have got to do. We have got to set our long-range plans quicker, have the people with the most foresight in those positions for long-range planning; we have got to set our long-range objectives early, and then we have got to devote a much larger portion of our funds to these initial exploratory phases.

The amounts are really very small compared with the amounts we can save downstream by giving us a fund af approaches carefully analyzed so when the requirement is there for the specific system we can pick the best one and not just the only one that is available.

Mr. KARTH. What you have said is precisely what some of us on the committee have been saying for a long time. We take too small a nibble or too small a step from one stage of advancement to another stage of advancement. It is not necessary that we learn how to walk four or five times before we learn how to run; once we learn how to walk we should make an effort to learn how to run.

Mr. TRUAX. Yes. We put one man up, then we put two up, and three up, and in this case we made a big step, went all the way from one man to three men with the Apollo.

Somebody discovered there was a loophole. We decided to put up two men. I hope we do not go to four men, five men, six men, one at a time.

There is a philosophy in the Navy—I speak as an ex-Naval officer—if you want to hit the target you fire it over and fire it short and this will bracket the target much faster than firing a successive number of shorts of gradually increasing range. I think we have got to take bigger steps.

Mr. KARTH. How much of the total R. & D. funds of the space program, both military and civilian, are actually spent on long-range, long-term planning, such as what you are suggesting? Do you have any idea?

Mr. TRUAX. It is an almost completely negligible fraction.

Mr. KARTH. Less than 1 percent, is it?

Mr. TRUAX. Yes. In the advanced propulsion technology, to take a field I know something about, the total amounts are in the neighborhood of $10 to $20 million, which, you can see, is an extremely small portion.

Mr. KARTH. When I say some of us on this committee have been saying precisely what you are saying, I don't want to leave the impression that the officials of the administration are necessarily and solely responsible.

You must understand that industry is always attempting to sell something, and in most cases—I hesitate to say this, but I think it is true—in most cases it is just these little nibbles or these very short steps in advancement one over the last one. So I think that if the people in industry would get together too, and present the same kind of testimony that you are presenting, take the same position that you are taking, look forward as far in advance as you are looking forward, then I think it would make it a lot easier for the Government to arrive at the proper decision.

The CHAIRMAN. Are there any questions?

Mr. Daddario?

Mr. DADDARIO. Mr. Corman had his hand up.

The CHAIRMAN. I was going down the line.

Mr. DADDARIO. I have a question, but later on.

The CHAIRMAN. Mr. Corman?

Mr. CORMAN. I want to ask either of the gentlemen whether you feel our efficiency is hurt by our becoming too responsive to the accomplishments of the Russians.

In other words, this business of trying to do something that they have done, has this caused us perhaps to change direction in midstream, or are we pretty well proceeding to our own objectives.

Mr. ROSS. My personal answer will be that it is not hurting but is probably helping us, because we are doing things that have to be done.

Mr. TRUAX. In line with my previous answer, I think we should not be stimulated to do what the Russians have just done, we should be stimulated by what they have just done to do something they have not yet done, and take a long enough range view of it to make sure that it is not the thing that they are already well on the way toward doing and will beat us at anyway.

I think actually the Russian accomplishments have stimulated us to a greater effort—and this is good—but I am not sure that what they do should have any direct bearing on our technical approach.

Mr. CORMAN. I would agree with your position.

I am only asking whether, in fact, are we becoming too responsive to their accomplishments, or are we doing what you say we should do.

Mr. TRUAX. Well, at the present time I do not think we are becoming too responsive. We were initially, I believe.

Mr. CORMAN. The other question I had was as to this problem of there being too much governmental supervision, particularly in the developmental stage.

I can appreciate how this would minimize your efficiency.

On the other hand, in view of the fact this area cannot be adequately controlled by competition, as we think of it in other fields, what is the answer to getting the maximum efficiency from private industry, being fair to all of those who are in or want to be in this field, and still be fair to the taxpayers, be sure we spend their money properly?

Mr. Ross. I am not really sure the two go together. The matter of supervision can be with or without competition. What I am speaking of is detailed supervision of project work. Instead of taking, for instance, 2 weeks to do a particular small segment of work, it might take 4 weeks because of all of the signatures required, and so forth, and formalization of just getting it going.

Now, it does not seem much when you say 2 weeks, but you are adding this on every little bit of a project and in total it adds up to a considerable amount of time, which comes back into real, I think, hard dollars.

Mr. Corman. Thank you.

The Chairman. Mr. Davis?

Mr. Davis. Dr. Ross, I would like to ask you a question about the chart there.

Mr. Ross. Yes, sir.

Mr. Davis. As respects the horizontal axis in your chart, is that pounds in orbit, is that the payload?

Mr. Ross. The cumulative pounds in orbit, yes.

Mr. Davis. Cumulative?

Mr. Ross. Yes.

Mr. Davis. To start with, it is 5.5 times 10 to the power of 6; that is the payload?

Mr. Ross. Yes. Five and a half million pounds.

Mr. Davis. Then it goes on over to 5.5 times 10 to the power of 9—at the end?

Mr. Ross. Yes. That would be 5,500 million.

Mr. Davis. Your cost, let's say, on the Astroplane, falls, at the end of your graph, to a price per pound of between $2 and $8, but am I correct in assuming that it would require 10,000 launches to produce that economy?

Mr. Ross. Yes; that is what the chart says.

Mr. Davis. And if you had only 1,000 launches with an Astroplane your cost would range somewhere between $8 and $20 per pound?

Mr. Ross. Eight and twenty; yes.

Mr. Davis. Then on the Saturn C–5, the line is remarkably straight on it, I see.

Mr. Ross. Well, I might say that you see quite a few numbers on projected cost of using Saturn. We have taken it in the same context as the other two studies.

So that there is bound to be difference in the absolute dollar.

I think what is more significant is the slope, which we have good confidence in.

The thickness of these lines sort of represents our confidence in the estimate.

We feel a little surer about a pure rocket. Something that is a flying machine I think has a little less confidence at this stage.

Mr. Davis. As a matter of being realistic, it would be highly speculative as to the total number of flights, wouldn't it?

That is getting pretty well out into the field of speculation?

Mr. Ross. I think we bracketed a reasonable range.

90751—62——10

Mr. DAVIS. I agree with you.

Mr. ROSS. It will be over this, certainly.

Mr. DAVIS. Yes.

Mr. ROSS. And this number of 5.5 times 10 to the 9 is rather a fantastic number.

Mr. DAVIS. It is, and 10,000 launches is a lot.

Mr. ROSS. Yes.

Mr. DAVIS. That is all I have, Mr. Chairman.

The CHAIRMAN. Mr. Waggonner?

Mr. WAGGONNER. Mr. Truax, in trying to accomplish what you have outlined, and in response to Mr. Corman's question that you think the long-range point of view would provide that we not just try to do step by step what the Russians have done but try to change our pattern a little bit now and try to go ahead and do things they have not done; using that philosophy, and the Russians having used simultaneously two cosmonauts, if we, for instance, jumped from one to four astronauts in our program and through some tragedy we lost those four men, wouldn't we be about out of the space program? We have been foresighted enough at the present time to bring qualified men into the program, although one has been now disqualified for physical reasons?

Where would be be then?

Mr. TRUAX. I happen to think that our astronaut training program is, let's say, superadequate.

I won't say that you could take a man off of the street and fly him in orbit tomorrow, but I think we have been so greatly concerned that the man not fail in this first part in our astronautic program that we have just bent over backward in giving them intensive training.

I think this in the future will be shortened tremendously.

Mr. WAGGONNER. I had anticipated that is what you might say. Do you think we could wisely abandon that philosophy of putting first of all the safety of that man above everything else?

Mr. TRUAX. I think it is probably very wise for early efforts, but it should be relaxed progressively in the future as we require larger and larger numbers of astronauts.

Mr. WAGGONNER. As the reliability of vehicles and capsules have been proven, you would say?

Mr. TRUAX. Yes.

Mr. WAGGONNER. That is all, Mr. Chairman.

The CHAIRMAN. Wouldn't you follow more or less the same program we have followed regarding test pilots? In the beginning of your business test pilots were rare.

Today nearly every company has its own test pilots.

All of the services have test pilots. These men have to have the same type of training.

Mr. Bell?

Mr. BELL. Mr. Truax. getting back to your philosophy, that Mr. Waggonner spoke of, relative to taking a big step instead of a short step, besides manpower, do you think this type of thinking should apply also to different types of propulsion systems?

For example, I note that your company has the contract on Project Rover—nuclear rocket vehicle.

Do you think all is being done that should be done in this direction? Should there be greater research done in this area or in the area of solid propellants?

Mr. TRUAX. I think with respect to Rover, to develop more effort is justifiable.

I think with respect to any concept which offers a major saving down the line that it is justifiable, because the amounts spent are so small.

Now, I happen to be one who thinks that it is far cheaper to make something bigger than it is to make it more sophisticated, but I do not know for sure whether this is true, and I don't think we will find out for sure until we have made a major size jump.

Now I guess to the same philosophy in a major technology jump also holds, but it is difficult to predict the date of new inventions.

Inventions in many respects just cannot be hurried by money. They can be hurried by making a more favorable climate. And there is one thing I think is extremely important, and that is our policy now of what we call independent research and development.

Essentially it works out to a situation where the company, if it puts in x percent, usually in the neighborhood of 50 percent profit dollars, the Government will go along with that to another 50 percent, provided the total amount being spent is 1 percent, I believe, or less than the total contract funds.

Now I think this procedure allows a company to use its own judgment in selecting what projections are good and bad with its own profit dollars as the controlling item, which keeps them from doing things that are inadvisable.

But I think it is inadequate because the level of participation is so high, when you look at the profit levels that are currently allowed, that it simply soaks up all the profit that is available and does not let us have nearly as big an independent research and development program as needed.

It amounts to admitting this concept, that there is some technical competence in the contractor's own people, that they do not have to have all their judgment always reviewed by someone in the Government as to whether or not it is good or bad.

We have a stable of at least 5 or 10 innovations which to me, and I have been in the business for over 20 years, look extremely promising. Every one of these concepts was developed under this almost minuscule research and development fund which is heavier on aerojet dollars and has yet to be backed with significant Government funding—yet in every case the Government has said, "Yes, this sounds like a good idea."

We use this to fill in, in other words, the time lag which it takes to educate the people in the Government as to what the idea is and to get them to put some money in the budget and get them to finally come up with a contract.

I think this R. & D. approach, where you let the company decide what is good, bad, or indifferent in their own technical field should be greatly amplified, maybe to the extent of 2 or 3 percent, or 4 percent, of the gross business.

It would allow me a tremendously improved flexibility and many of the ideas that get killed aborning because we do not have the funds to explore them adequately could be developed and reduced.

Mr. BELL. You think a substantial step would be taken in improving our situation to the big step if the Government were to participate a little more heavily in the original R. & D. work that is being done in industry?

Mr. TRUAX. Financially?

Mr. BELL. Yes.

Mr. TRUAX. But not administratively. We need a great fund of new ideas gradually being winnowed and reduced in number as they are increased in scope financially.

The CHAIRMAN. May I interrupt to say I just received word that tomorrow morning at 10 o'clock we will meet in executive session.

Mr. Webb is coming up to tell us about the twin Russian astronauts. Now he has to leave at 11. He will have other people with him. We hope to have Mr. Gilpatric here too.

That is not firm as of now.

I therefore ask you all to be here, if you want to hear Mr. Webb, at 10 o'clock tomorrow morning. Excuse the interruption.

Thank you.

Mr. BELL. Just one other question.

Getting to a little more specific question, Mr. Truax, relative to the Rover program, do you feel there has been or is a delay in any way that you are suffering as a result of lack of reactors to be furnished to the program out in Nevada?

Mr. TRUAX. This has been out of my line. I think maybe Mr. Ross could answer the question better.

Mr. ROSS. Currently the critical areas are reactors and facilities. I think they are about even.

Mr. BELL. That is all, Mr. Chairman.

The CHAIRMAN. Mr. Roudebush?

Mr. ROUDEBUSH. I would like to probe deeper into this astronaut training, Mr. Truax.

You said you thought it could be greatly shortened as to time, and so forth.

What particular aspects of that program do you disagree with in its present status?

Do you think it is repetitious, for example, or do you think there are things being done to our astronauts that could well be dispensed with? Just how would you shorten such a program?

Mr. TRUAX. It depends on what the astronaut has to do, of course. In a perfectly passive mission chances are you could pull a man in off the street and he would survive the operation.

You might be unlucky and find one that had a heart condition and could not take the reentry. If he has a more active role he has to have training, I would say about equivalent to a test pilot's training.

I don't see that the job is fundamentally so much more difficult that he needs to have training that far exceeds the training of a test pilot.

Again, I am a little out of my field. I happen to be an ex-aviator, but aside from what I read in the newspapers I do not know the details.

Mr. ROUDEBUSH. I more or less like your idea.

I wonder if you feel, for example, the two original suborbital flights by Shepard and Grissom—do you think the Grissom flight was unnecessary and repetitious? Did we learn as much as we did from Shepard's flight?

Could it have been dispensed with without hurting our program and providing necessary information to us?

Mr. TRUAX. I am sure I will rub someone the wrong way with this answer, but when I sat on the Man-in-Space Committee, that program was proposed and I was one that voted against it. I have not changed my mind since.

Mr. ROUDEBUSH. What about the Glenn-Carpenter orbital flights; do you think the Carpenter flight was repetitious and duplicating to that of Colonel Glenn's?

Do you think we learned anything of great value to our scientific endeavor through a second orbital flight?

I know the Russians do not do these things. Each of their type of experimentation with men in space apparently—to me is something unique and new, while ours, it seems we go into these programs, we do one thing and repeat it.

Do you think that is useless duplication?

Mr. TRUAX. It is not as useful as it ought to be. I think when we plan any program we always ought to ask ourselves at the outset when it is over what is the next step and see how that step feeds into the next step and if it does not we should adjust the program so it does contribute a little bit more.

If our only objective of the man-in-space program was to beat the Russians with a man in space it would have been achieved by the Carpenter and other flights.

But since it was a minimum capability type of thing, again under the pressure of trying to be first, it is rather dead-ended. I would have taken a different approach, giving us more capability, so that in answer to the question, What do you do after the first shot? You have enough payload capability in the vehicle from the outset to try a two-man shot, not just for the sake of having two men up there, but for the sake of letting one get out and see whether he can perform, say, assembly operations in space.

Normally it would probably be somewhat foolhardy for a single man to get out without a safety, but with two men you can do this. You can see how a person operates.

We talk of assembling things in space. Is this something a man can actually get out and do?

That is something that could be performed with a two-man vehicle.

When we finance our Apollo program, the man lands on the Moon, or three men, or however many they finally come up with, I am sure we do not simply want him to grab up a handful of Moon dust and throw it in the air and plant our flag alongside of the Russians and say that is all, this is what we spent the $40 billion for.

We are going to do something beyond that.

Undoubtedly we will explore the Moon. It will take a lot of people and equipment. It is a big task.

After that we may have a permanent Moon base. I don't know what for, but I think we will know by that time.

After that, we will be going to Mars, and so on down the line. We have to plan our program always so that the maximum amount of equipment and techniques that we develop in getting to our first objective will apply to the next objective.

Mr. RANDALL. Will you yield?

Mr. ROUDEBUSH. Yes.

Mr. RANDALL. On this question, about the Moon dust, and so forth, the question came to mind, tied in with the gentleman from Indiana's question about the astronauts, do you believe—you said you were on some kind of a board and that you voted against this repetition so I think it is a proper question—do you believe that the astronauts should be men, in the future, who have some scientific training—scientists, in other words—instead of simply test pilot experience?

The reason I ask that, I believe it was Glenn who described it as fireflies, and so forth—another one said there were bubbles.

When we get to the Moon is it your feeling we should have someone trained in science as an astronaut?

Mr. TRUAX. I think we should.

I don't intend to downrate the technical competence of the present group of astronauts. They are highly competent technical people.

I think we do have knowledge now about what functions these men will perform when they get there and make sure they have the background.

I think the tendency will be in the direction for them to have more scientific and engineering background.

Mr. RANDALL. Thank you.

Mr. ROUDEBUSH. That is all I have, Mr. Chairman.

The CHAIRMAN. Mr. Daddario?

Mr. DADDARIO. Dr. Ross, if we could refer to your conclusions and recommendations for a moment, you said that there is some recovery work—water recovery work—going on but not sufficient work in extreme large scale—in fact, you think none is contemplated, to your knowledge.

What kind of large-scale engines are you talking about, in what proportion to the C–5?

Mr. ROSS. I think a factor of 10, at least.

In other words, instead of a million pounds, 10 million.

Mr. DADDARIO. What would your recommendations be in reference to that? How would we get this kind of a program underway?

How soon should we get it underway?

How do we build it up on top of what we are doing now and what are the estimates of cost?

Mr. ROSS. Mr. Truax has been studying this. I suggest he answer.

Mr. TRAUX. One of the difficulties is the settling of our national goals.

It was only about a year and a half ago—it seems like I am always sitting on committees—I was on another committee, where one of the main complaints of the NASA people on that committee was that the national objective to put a man on the Moon had not yet been set, and this objective was the only one that they could see which required a very large engine.

So one of the first things we have to do is set forth some firm national objectives.

Are we, in fact, going to explore the Moon after we land a man? Are we going to go on to the planets?

This provides the basic justification for going into these bigger engine developments, for example.

Then we have to find such developments and have to hold very rigorously to that kind of advanced work in the face of the financial demands of the present programs.

I think the step, propulsionwise and "everywise," should be big enough so that it is a significant one.

Mr. Daddario. This recommendation is included in your statement—Dr. Ross' statement—it says that the conclusions and recommendations which are the result of these studies are summarized as follows, and therefore if you do say it, what statistics do you have to back it up, and how do you get it underway, and what will it accomplish, taking into consideration that there are various achievements that can be realized once these other goals are attained?

Once we get to the Moon I am sure we will not just take a look around and come back, we will certainly conduct scientific experiments. You have made the statement we need extremely large scale engines and you have a study to support it.

What is the study, what will it cost, what will it accomplish, how do we get it underway, how does it fit in our program?

Mr. Truax. These studies are based on the assumption that we are going to have a continuing space program of at least the present financial magnitude.

There are some people that think that when the man on the Moon program is over we are done.

If you make that assumption, then you come almost inevitably to the conclusion you want even bigger engines.

The only thing that has to be done is to appropriate the money and accept the proposals that have been made by industry and go on ahead with it.

The Chairman. We have another witness. We have taken a good deal of time here.

Mr. Morris?

Mr. Morris. I am sorry I was not here while your statement was read. As I understand the conclusions that you make in your statement, one of them is that you would save money in the area of the space program if you would recover boosters?

Mr. Ross. Yes, sir.

Mr. Morris. And, two, that you think that there should be a program going as far as recovery on land of the vehicle?

Mr. Ross. We do not propose immediately a full program of this type. We think that there are areas—both of these studies, which sort of bracket the situation of recoverable boosters, require certain feasibility demonstrations in various areas.

Mr. Morris. I understand. You would not go into a program, I assume, unless it was technically and financially feasible?

Mr. Ross. That is right.

Mr. Morris. Any program that you would propose naturally would, I assume, would be backed up by feasibility studies?

Mr. Ross. We believe that the feasibility should be done, and it will be rather costly to do it.

We believe we should work on engines of the order of 10 million pounds thrust, or perhaps larger single engines.

Let's see what the problems are. No one can say what they are. In our experience since the early experience in developing rockets, to 200 pounds, from 200 to 5,000, from 5,000 to about 30,000, 20,000 to 150,000, something changed each time.

One would be easy, the next hard. The big jump—there is no one can tell you what will happen. It might turn out to be a very simple thing. We would be really ahead if it were.

Mr. Morris. I won't take any more time. I don't understand your answer.

The Chairman. I was going to say to Mr. Truax—I was very much interested in his statement about the astronauts—but before we sent these astronauts up we did not know very much about weightlessness, we have 10 hours' experience with it now—unless the Russians give us their 80 hours.

Do you think that we can entirely neglect the field of bioastronautics when we talk about going to the Moon, and getting through these belts, and all that sort of thing? Are you ready to make predictions now as glibly as you make them to criticize the past for the things that we don't know in the future? We don't know too much about the future.

Mr. Truax. No, indeed, but there is such a thing as being overcautious—that is my only point.

The Chairman. Are we being overcautious now when we don't know?

We know now something about weightlessness.

May I ask you, could you have made these statements as positively as you make them now, would you have made them before these flights, when we knew nothing about this?

It would be very easy to say sure, you would take this big step, but would you have made them a year ago with the positiveness that you make them now?

Mr. Truax. I am trying to recall whether it is in the record any place.

As a matter of fact, I did.

The Chairman. You were one of the best then. There were not many that were willing to stick their necks out.

Mr. Truax. There is always a chance there is a burglar under the bed but we should not spend too much time and money worrying about the burglar under the bed.

The time will come when one of these astronauts will get killed. It will come no matter how much we bend over backward trying to prevent it.

The Chairman. Mr. Truax, I think I never overlooked an opportunity on television or radio or in speeches to point out the fact that every time we have developed a new plane we have lost two test pilots and that we have got to face this situation.

This is true, we recognize this, but I recognize also that there are some factors that we are not familiar with here that have to be resolved before we go into this thing.

Not to argue with you about this now—I am concerned with what we can do in this program to make sure that we are getting a dollar's worth of service for every dollar that we spend.

We want industry to come here—we invited you here—we want you to come here for this.

Now maybe we are too cautious, but I think that we have recognized the value of human life, and we have hesitated to go too fast.

Maybe this is our trouble.

Maybe we have gone over this hurdle and should hurry along now.

Mr. TRUAX. I am really much more concerned about being technically overcautious than I am about being overcautious about human life and safety.

The CHAIRMAN. I think that is it. I think you reflect the spirit of the techniques, without considering all of the other facets that go into this thing, and bioastronautics and life is part of it.

You speak as an engineer. I can understand your position. You add up two and two and always get four.

I think, with your permission, we will go on to the next witness.

Thank you very much, gentlemen.

We have Mr. Trimble here. We also held him up the other day.

Thank you very much for your very provocative statements.

The CHAIRMAN. Mr. Trimble, we welcome you here, sir.

Mr. TRIMBLE. Thank you, Mr. Chairman.

The CHAIRMAN. Will you proceed with your statement, sir?

STATEMENT OF GEORGE S. TRIMBLE, VICE PRESIDENT, MARTIN CO., BALTIMORE, MD.

Mr. TRIMBLE. Chairman Miller, members of the Committee on Science and Astronautics of the House of Representatives:

I am George S. Trimble, vice president for advanced programs of the Martin Co., Baltimore, Md. Our company constitutes the Aerospace Division of Martin Marietta Corp.

For a number of years, Martin has been actively engaged as an industrial participant in the Nation's defense effort and, more recently, in its space program.

Our activities are concerned primarily with the study, design, development, and production of missile and space systems, electronic components and systems, and related nuclear power applications. We maintain research and manufacturing facilities at Baltimore, Denver, Colo., and Orlando, Fla., as well as a flight test facility at Cape Canaveral.

We welcome the opportunity to participate in the committee's hearings, which we believe will make a significant and constructive contribution to the success and progress of our national space effort.

Let me assure you that we are in full and complete accord with the objectives of this committee in seeking ways and means of achieving national space goals with the maximum degree of economy possible.

We all recognize that substantial benefits will accrue from the space program that the Nation has undertaken. This was clearly and force-fully stated by the chairman of this committee, Congressman Miller, in his address before the American Astronautical Society last January.

At the same time, we recognize also that this effort will entail substantial expenditures.

In his testimony before the House Appropriations Subcommittee in April, Mr. James E. Webb, the National Aeronautics and Space Administrator, estimated that total costs of all NASA programs for the next 10 years would amount to about $35 billion.

This, of course, does not include the space activities of the Department of Defense. Expenditures of the magnitude contemplated impose a fundamental obligation upon all who have a part in the space program—in Government and industry—to see that the American taxpayers receive full value for their space investment.

I want to assure members of this committee that the Martin Co. is acutely aware of this obligation and seeks at all times to discharge it.

To us, this means making the wisest use of our scientific resources and management skills in order to produce quality goods at minimum costs.

In my discussion today, I would like to emphasize two principal areas of potential economies in the space program:

First, I would like to discuss what we consider to be primarily the contractor's responsibility for exercising management and engineering controls to bring about immediate and direct savings in individual project costs.

Second, I would like to indicate some areas of technical program development which we believe could lead to the most economical, long-range solutions to overall space problems.

In our view, the contractor's responsibility for cost reduction is an all-encompassing effort that begins at contract inception and continues throughout the life of a program—from design through fabrication and delivery.

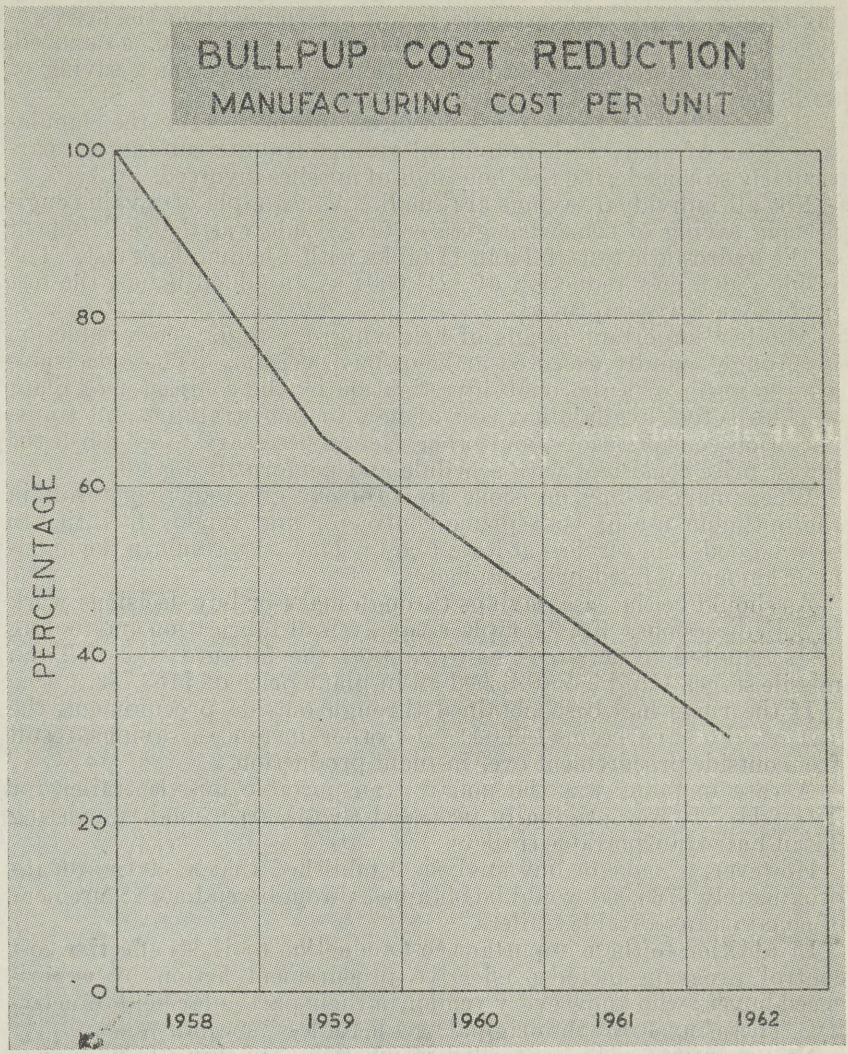
This view, I feel confident, is shared by our entire industry. While I have general knowledge of what the industry as a whole is doing to reduce costs and induce economies, I can speak more specifically about our own activities.

To illustrate what can be accomplished as a result of contractor cost reduction efforts, I would like to cite our experience in two different programs for which we are principal or prime contractor.

A vigorous and coordinated cost reduction effort succeeded in reducing Titan costs last year by $16.5 million below programed costs. This year the goal is a reduction of $40 million, and we're over halfway toward achieving it.

In the case of Bullpup, an air-to-surface missile produced in volume for the Navy and Air Force, the per-missile cost has been reduced by more than 70 percent since production began in 1958 with no impairment in the missile's performance. (See figure I.)

FIGURE I



This is figure I, which shows the percentage reduction in costs for the missile with time.

Obviously, a great many factors were responsible for these results. Cost reduction of this type, like perfection, is the summation of many individual detailed efforts.

Let me give you a few examples of the principal techniques industry has developed that make such reductions possible.

One of the most important of these techniques is called value engineering. By this we mean a tough and thorough item-by-item examination of procedures, fabrication methods, materials selection and design modifications to seek out those which will reduce costs without compromising performance.

Sometimes the individual item saving resulting from value engineering is quite small. For example, it was determined that the nose section electrical checkout plug on the Bullpup missile could be removed, and the associated fabrication operations eliminated, at a saving of $2.28 per missile.

By itself this saving might seem inconsequential. But the cumulative effect of many such individual savings is quite substantial, particularly so considering the thousands of missiles involved.

Not all individual savings are small. An example of a value engineering saving of somewhat greater magnitude was the replacement of the hydrostatic test of Titan II tanks with a helium leak test. The result was a cost reduction of $241,000; as an added bonus, the test performance was improved.

Another important means of achieving day-to-day cost reduction is through soundly executed make-or-buy decisions. These decisions are the result of a thorough investigation by the contractor of plant workload, tool availability, cost of new tooling, training and transportation considerations, and other factors necessary to establish the lowest price consistent with schedule and performance goals.

When make-or-buy decisions are properly effected, they result in the optimum use of both prime contractor and vendor facilities to obtain goods and services at lowest cost. They also result in the maximum amount of fixed-price purchases.

As should be the case, savings through make-or-buy decisions work in both directions. For example, an analysis of fabrication and tooling costs required to obtain rings to support the forward end of Titan missile stages 1 and 2 established an in-plant price of $133,773.

If the rings had been obtained through outside procurement, the cost would have been $143,000. In other instances, savings result from outside procurement over in-plant production.

A case in point was the nonair transportable missile trailer for Titan II. It was originally proposed that Martin modify existing Titan I air-transportable trailers.

However, a make-or-buy analysis established that a saving of approximately $760,000 would be obtained through vendor procurement of nonair transportable trailers.

In addition to these important cost reduction tools, an effective cost control program includes effective procurement action by experienced buyers who know every vendor in their particular field of activity. These buyers are the original "get it for less" specialists.

No program can be controlled if what is happening is unknown. Therefore, a precise system of financial reporting must be maintained to produce vital data in time to influence results.

The key problem here is one of obtaining the needed data without strangling the freedom of action essential to an efficient program.

At Martin, we attempt to weed out unnecessary data reporting by continually asking: "Are we really using it?" and, "If we didn't have it, what would it cost us in terms of effective control?"

I turn next to an entirely different aspect of contractor responsibility for obtaining maximum mission performance at the lowest cost. This has to do with system reliability. Nothing is more expensive—not to mention frustrating—in terms of results than the operation that fails. Reliability, therefore, bears heavily on overall space program costs.

All of us recognize that an extremely thorough testing program at every stage of development is vital to attain the necessarily high standards of reliability required in space systems. An equally important consideration, in my opinion, is that reliability must begin with the design concept.

Complexity inherently lowers system reliability simply because there are more things that can go wrong. The probability of failure increases almost directly with the number of components.

The contractor, therefore, must design reliability into his product beginning at the conceptual stage by using his engineering ingenuity and resourcefulness to achieve the highest degree of simplification possible.

Such simplicity does not come easily but must be achieved through experience and hard work. However, it can be done.

One example of which we are particularly proud is the improvements and simplifications that have been made in Titan II over Titan I.

Although Titan I has achieved an enviable record for reliability (only four failures in 47 flight tests from Cape Canaveral), we expect Titan II to establish an even better record. This chart explains why. (See fig. II.)

FIGURE II

TITAN I VS. TITAN II SIMPLIFICATION

	TITAN I	TITAN II
AIRBORNE		
RELAYS	49	7
UMBILICALS	32	4
VALVES AND REGULATORS	91	16
GROUND EQUIPMENT		
PERIODIC CHECKOUT FUNCTIONS	322	35
LAUNCH FUNCTION	230	23
MAJOR UNDERGROUND STRUCTURES	42	18
UNDERGROUND TUNNELS (FT)	6,000	945
POWER REQUIREMENTS (KW)	12,000	2,700
SQUADRON CHASSIS REQUIREMENTS	945	414
ELEVATOR COMPONENTS (PER SQUADRON)	13,050	0
GROUND GUIDANCE RACK	111	36
PTTS COMPONENTS (PER SQUADRON)	5,640	1,355
INTERCONNECTING CABLES (PER MISSILE)		
TOTAL CABLES	194	80
TOTAL WIRES	3,500	1,900
TOTAL TERMINATIONS	8,100	3,840

As you can see, Titan II has one-seventh as many relays as Titan I, one-eighth as many umbilicals and about one-sixth as many valves and regulators.

There are similar significant reductions in ground support equipment and functions required for Titan II. Moreover, we estimate that Titan II's "in the field" cost will be approximately 40 percent less than the equivalent costs for Titan I.

The technological and design advances of Titan II were achieved through the combined efforts of the Titan industrial team and the Air Force Ballistic Systems Division.

In addition to increasing reliability and thereby reducing costs, simplification results in substantial corollary savings in such areas as training, maintenance, and basing.

It is our feeling, therefore, that in evaluating future space systems, major emphasis should be given to basic design simplicity. We believe that much more can be accomplished and that members of our industry should devote even greater effort to finding simple, inherently reliable solutions as part of their design proposals.

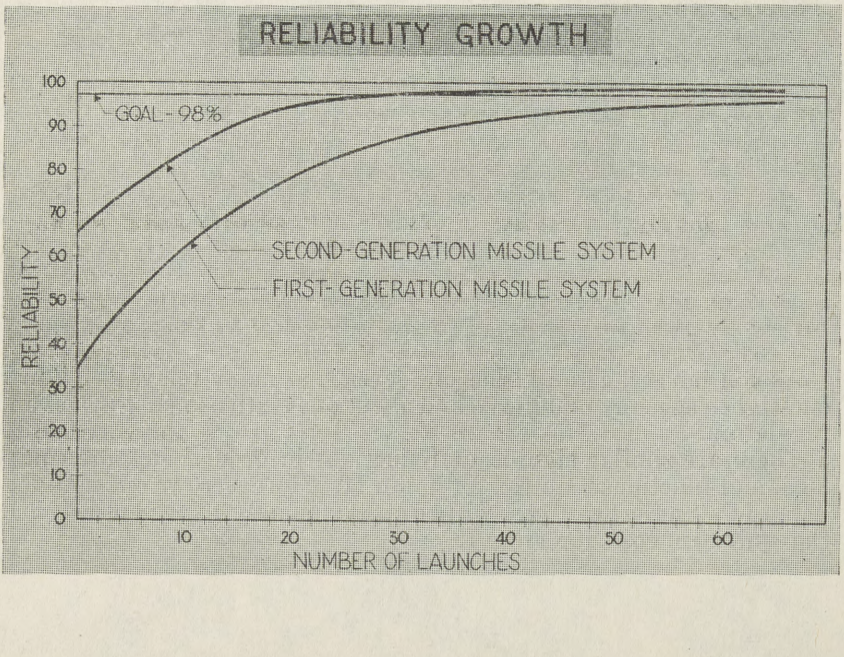
I would like to add one further comment on the subject of reliability. Along with the design simplicity, I think we must make greater use of standardized parts and components in space systems development. This would have a twofold result: first, it would reduce the number of components that must be developed and proven; second, it would reduce procurement costs.

The problem of component standardization is by no means new to the space age. In 1870, a Frenchman named Charles Renard, who was concerned with early use of observation balloons for aerial communications, found that the French Army listed no fewer than 425 different sizes of cordage for mooring balloons.

In attempting to determine the optimum diameter for the cordage, Renard hit upon the principle of establishing a geometric progression of sizes. As a result of his discovery, the 425 different sizes previously required to do the job were reduced to 17.

As our space program develops we should keep in mind what Mr. Renard did for observation balloons. If we can similarly reduce the variety of life-support systems, power supplies, connectors, and other components, the standardized item can be more thoroughly refined and tested with a corresponding increase in reliability for the same total effort. (See fig. III.)

FIGURE III



Here we have a plot of reliability versus a number of launches for a typical rocket.

As you can see from the chart, a new system starts off with quite low reliability and slowly gets better and better as more and more are fired.

Furthermore, the smaller variety of each component would result in larger quantity production at lower per-unit cost.

What I have been saying about reliability comes down to this: Design simplicity and component standardization, together with vigorous testing of the total system, will mean fewer mission failures and consequently, significant savings in the cost of the overall space effort.

Up to now, I have discussed the management and engineering aspects of cost reduction.

Next, I propose to speak more to the point of the technical aspects of the program which we feel could have a major impact upon the long-term costs of achieving our space objectives.

I should emphasize that my remarks are based on a strong personal conviction that we should continue to support a vigorous and expanding space program and that we must seek overall solutions to the problems involved.

This committee certainly is familiar with the extensive debate that has surrounded our space program over whether man in space is a help or a hindrance.

Thanks largely to the experience our astronauts already have obtained, I think the issue has been largely resolved in favor of man.

But for the record, let us briefly review the arguments on both sides.

The main arguments usually advanced against manned space systems have been:

(1) Provision must be made for his survival.

(2) His presence adds weight and complexity to the system.

(3) Many of his functions can be done by automatic equipment.

On the other hand, the main arguments for man in space have generally been there:

(1) His decision faculties are greater and better than any machine.

(2) He separates the important from the unimportant and can act as a switching network.

(3) He is a better observer than a machine.

(4) He can maintain, adjust, and calibrate.

(5) He has a maximum mission flexibility.

(6) He acts as a backup network for critical subsystems.

The X–15 program provides indisputable evidence of man's value in the operation and recovery of an aerospace vehicle. It is estimated that more than 40 percent of all X–15 flights would have resulted in either complete failure or loss of test information if a pilot had not been aboard to correct malfunctions and to retain essential flight information which otherwise would have been lost by instrumentation failure.

About a year ago, we performed a study applying pilot functions as performed in airline operations to failure modes in missile system operation. We examined actual 1960 statistics of a major airline, and our subsequent reliability analysis concluded that the pilot's function decreased aircraft failures rate by a factor of 870.

Comparing aircraft malfunctions with equivalent missile malfunctions that would have caused complete loss of a vehicle; that is, engine failure, et cetera, we determined that without the pilot aboard one major airline would have had only 14 percent of its original fleet surviving at the end of 1960.

We have performed further studies aimed at identifying potential value in reusable launch vehicles. A sequence of 35 vehicle recovery events were analyzed comparing individual reliabilities for each event performed in an unmanned versus a manned system.

These events covered 10 major vehicle subsystems such as engines, guidance, flight controls, hydraulics, et cetera. Our calculations showed that 12 times as many manned as unmanned vehicles would be recovered successfully.

An analysis of Discoverer satellite recoveries attempted through the first quarter of 1961 revealed that 5 out of 12 orbiting satellites, intended for recovery, had successful recoveries.

Examination of the seven losses indicate the causative malfunctions to be of the kind that manual backup has overriden successfully in recent experience on Mercury flights.

Consequently, we are convinced that manned operation and maintenance of space vehicles will constitute a major long-term economy in the national space program.

Therefore, we strongly recommend that a man-in-space capability continue to receive the highest priority to the end that this capability will be achieved at the earliest possible time.

Now, I would like to discuss a concept which is a little further in the future. This concept, which has an impact on many diverse space objectives, is orbital basing—by which I mean the placement in space of manned stations capable of serving as scientific laboratories and as mission support and control bases for both manned and unmanned operations.

For missions requiring sustained patrol, frequent repetition, recurrent sampling, crew replacement and acquisition of scientific data under varying conditions, we believe that notable economies will result from basing semipermanent mission support stations in the orbital "theater of operations."

The alternative, as we know today, is the launch from an earth base and recovery of the entire mission vehicle back to an earth-based support station.

The orbital basing concept could employ a reusable launch vehicle or aerospace plane in the role of a scheduled cargo carrier.

This reusable cargo carrier would be used to take the relatively small mission vehicles into orbit, to resupply the mother station, and to bring crews and mission vehicles back from orbit.

Under this operational mode, the mission vehicles could remain relatively small since the sorties would be of relatively short duration and would not carry provision for reentry.

They would stay in the orbital theater for sustained periods, and would attach to the mother station for refueling, pilot exchange, repair, and mission orders. Even the particular instruments carried could be exchanged for greater flexibility.

Moreover, such an orbital base would provide an excellent point of departure for missions into deep space.

The technical requirements for reliable orbital basing are effective life support systems; modular station structures; precision delivery, rendezvous, and docking of payloads; orbital refueling systems; interchangeable mission modules; and flight data integration display systems.

All of these engineering requirements are basic to effective performance of any space mission vehicle, and many of them are currently under development.

It would be possible, however, to direct their development even more effectively under an integrated program geared to orbital basing.

With orbital basing, we would derive maximum utilization and service life from payloads which must be launched into space at considerable cost.

Accordingly, we recommend that development of the orbital base be initiated at the earliest possible time in order to provide the maximum long-range space capability at minimum cost.

I have mentioned the reusable or recoverable booster in connection with the orbital base concept. It also has considerable importance in other recurring missions.

Estimates of direct launch expenses generally agree that it costs between $1,000 and $2,000 with today's launch vehicles to place 1 pound of payload in an orbit 300 miles high. The newest nonrecoverable boosters such as Saturn C–5 and 624A will provide a significant reduction in direct launch costs to about $300 or $400 per pound in orbit.

Some concepts now under discussion, such as a single stage to orbit, offer still further reductions—perhaps to less than $100 per pound.

Even at this rate our national space program will be very expensive. However, the concept of recovery and reuse carries a dramatic potential for economic savings providing the number of launches of a given vehicle is large enough.

In fact, estimates have been made predicting direct launch costs as low as $25 per pound in orbit for several hundred launches. (See fig. IV.)

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FIGURE IV

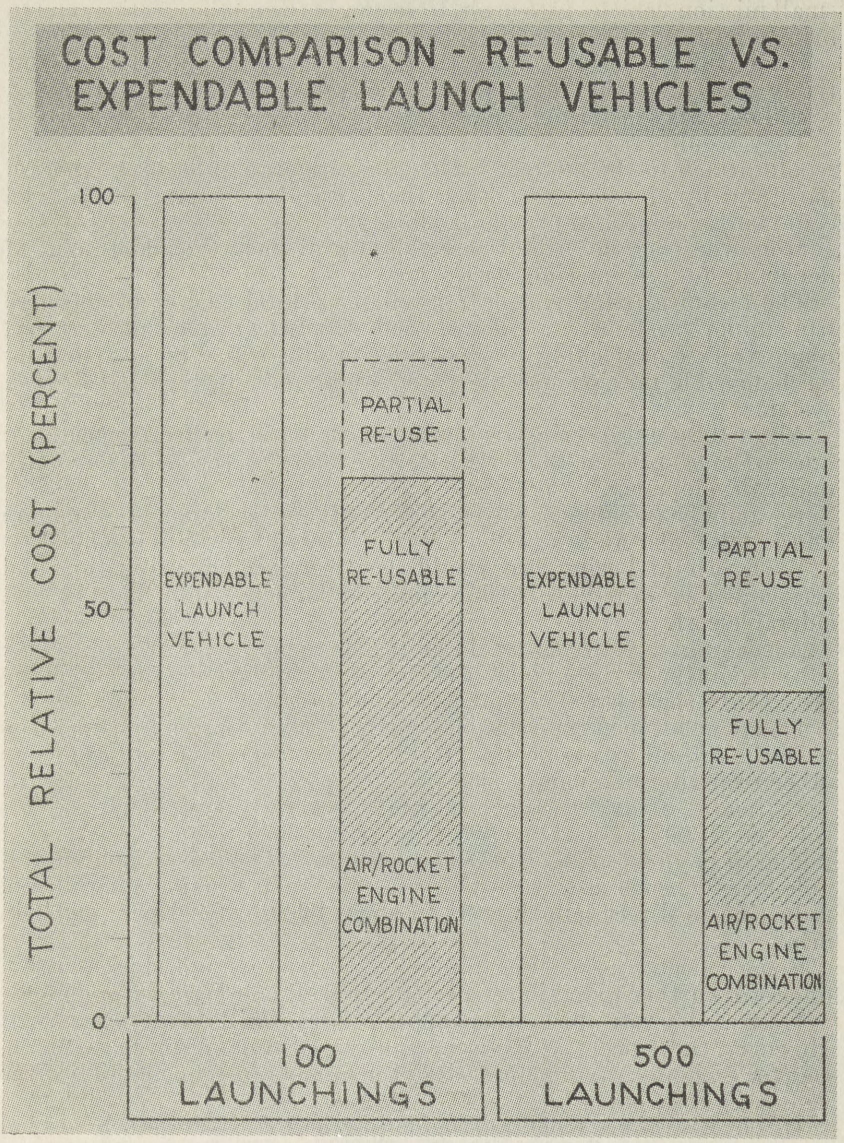

Figure IV reflects what I believe you have already heard, that on an expendable launch vehicle if it costs a hundred for a hundred launchings fully reusable one would drop to about 68.

For 500 launchings, down to 40 percent of the expendable launch vehicle cost.

We feel that at the present time there is insufficient knowledge available to resolve clearly the cost competition between the various possible systems, that is, between expendable boosters, partially recoverable boosters recovering only the first stage, and fully recoverable boosters such as an aerospace plane. Specifically, we must know answers to questions such as these:

(1) How many launches will be made over what period and what total payload must be launched?

(2) What is the lowest direct launch cost that can be obtained with advanced expendable boosters?

(3) What is the development cost of an effective reusable system?

(4) Will the development of a near-optimum reusable launch system be a single step or a number of incremental steps?

I might add as an aside that the cost of the propellant which will supply enough energy to put 1 pound in orbit is only about 35 cents, so that this presumably would be the end point, you couldn't do the job any cheaper than what the energy or the chemicals cost.

Because of the very large sums involved in direct launch operations, we recommend that high priority be given to the determination of the relative costs of these various approaches so that the most economical system can be selected and development begun.

In summary, I have cited several areas where cost savings may be accomplished—especially by the contractor—and I have identified several program objectives which I believe are fundamental to the development of a true space capability in an economical manner.

The early accomplishment of these program objectives sets the stage for a practical drive into space, based on man and versatile systems which will not suffer from early obsolescence.

These items obviously do not represent the total spectrum of possible cost-saving actions, but they are those of which I have some knowledge and experience.

The CHAIRMAN. Thank you very much, Mr. Trimble.

Mr. Karth?

Mr. KARTH. No questions.

The CHAIRMAN. Mr. Chenoweth?

Mr. CHENOWETH. Mr. Trimble, I, of course, want you to know we in Colorado are very proud of Martin's operations.

We feel they are making most substantial contributions to the whole space program.

Mr. TRIMBLE. Thank you, sir.

Mr. CHENOWETH. I want to compliment you on this very tremendous statement. It is certainly very well prepared.

And you have presented some very challenging proposals here.

I want to commend Martin on the fact that you are saving money, that you have been able to effect these cost-saving devices and programs.

Do you think we can go further? Don't you think it is essential in this program, which is taking so much of our national income, that every manufacturer, every concern having any part of the missile program, exert every possible effort to save a dollar where possible?

Mr. TRIMBLE. I certainly do.

Mr. CHENOWETH. Would that be a fair challenge to make?

Mr. TRIMBLE. Yes, I think that is part of the job of being a contractor, and I also think that at any one space in time we can always do better.

Mr. CHENOWETH. You have been demonstrating with Titan II the improvements you have made over Titan I.

You have commented on the great number of parts you have eliminated.

Mr. TRIMBLE. We don't do all of that. Our Aerojet friends have had a hand in it.

Of course, the Air Force folks were behind us all the way, too.

Mr. CHENOWETH. What is the present status of Titan II, where are we?

Mr. TRIMBLE. We fired four, and two worked and two didn't.

Mr. CHENOWETH. When was your last firing of Titan II?

Mr. TRIMBLE. The day before I was here last. July 25.

Mr. CHENOWETH. Was that a success?

Mr. TRIMBLE. Partially. It was not totally successful.

Mr. CHENOWETH. You are still perfecting Titan II?

Mr. TRIMBLE. Yes. We have only fired four and expect to fire quite a few more before we have that perfected.

Mr. CHENOWETH. How long has Martin been in the missile program now?

Mr. TRIMBLE. How long?

Mr. CHENOWETH. How long? You started before you went to Denver, didn't you?

Mr. TRIMBLE. I think our first rocket program was 1948, Viking rocket, which we did for the Navy.

Mr. CHENOWETH. When did you establish the Denver plant?

Mr. TRIMBLE. 1956.

Mr. CHENOWETH. That is when you started your Titan operation?

Mr. TRIMBLE. Yes.

Mr. CHENOWETH. You are devoting all of your Denver operations to Titan now, are you—Titan II?

Mr. TRIMBLE. Yes.

Mr. CHENOWETH. You feel that you are getting fairly close now to having Titan II in operational condition?

Mr. TRIMBLE. Not Titan II. It has quite a way to go. Titan I is operational.

Mr. CHENOWETH. On Titan II what would be your time estimate, roughly?

Mr. TRIMBLE. I don't know.

Mr. CHENOWETH. I don't mean to commit you. I was wondering what that would be.

Mr. TRIMBLE. I don't know and I am not sure of the classification of the date.

Mr. CHENOWETH. I don't care for anything that is classified.

What would your observation be on our overall space and missile program now, Mr. Trimble, if you were making one?

Do you feel we are making substantial progress? You can speak for the Martin Co. What is your observation on the whole overall picture? We hear so much about the Russians, what they are doing.

I am concerned with what we are doing. Do you think we are going fast enough, too fast, spending too much, not enough. What would your observation be?

Mr. TRIMBLE. My feeling is that we are meeting objectives that we have formalized in this country. The objectives we formalized have nothing to do with beating the Russians. At least the ones I have seen. They say we are going to explore space for peaceful uses of all mankind. I think we are doing that.

As I remember the objectives, there was little in there about haste. We have the objective of putting a man on the Moon and return by 1970, and I think the program that is now in existence will do that.

Mr. CHENOWETH. Do you think that is a program that we should follow? Should there be a change in that?

Mr. TRIMBLE. No.

Mr. CHENOWETH. Do you see any reason for a change at this time?

Mr. TRIMBLE. No, not in my mind.

I think the objectives are good. I think most of our arguments, most of our misunderstandings, derive because people tend to lose sight of the objectives that we have.

Mr. CHENOWETH. What should be our chief objective in this space missile program? Not just merely to put the man on the Moon—that certainly is not it.

Mr. TRIMBLE. No.

Mr. CHENOWETH. $40 billion to spend on it.

What is our main program? People are asking that question right along.

Mr. TRIMBLE. I think what you gentlemen have written into the Space Act of 1958 is a very fine statement of objective.

Mr. CHENOWETH. Then you feel fairly well satisfied with what we are doing and the program we have and the manner in which we are implementing it.

Would that be a fair statement?

Mr. TRIMBLE. I would say so. By nature I am never satisfied with anything—but neither is anybody else, I guess.

Mr. CHENOWETH. We never want to be satisfied. You feel we are making substantial progress.

Mr. TRIMBLE. I certainly do.

Mr. CHENOWETH. In these objectives?

Mr. TRIMBLE. Yes.

Mr. CHENOWETH. You know of no reason to change any objectives at the moment; you think they best carry out what we should be seeking in our space program?

Mr. TRIMBLE. The only thing I do say there is, that although I have been unable to find any formal objective for getting some place before the Russians do, there certainly is an awful lot of talk about that, and I think we either ought to make it an objective or decide it is not an objective and get some kind of understanding on that subject.

Mr. CHENOWETH. You feel we are going as fast as we can now in these different programs?

Mr. TRIMBLE. No, we are not going as fast as possible, but you never can, because we can't do everything, we have to do other things. We can't spend the entire national budget on the space program. We can only spend so much.

Mr. CHENOWETH. We have to keep things in their relative importance.

Mr. TRIMBLE. Yes.

Mr. CHENOWETH. Do you feel space is occupying and taking enough of our income, or should we devote more time and attention to it?

Mr. TRIMBLE. I think if I had to choose I would not make it larger. I would not spend more.

Mr. CHENOWETH. You would keep it about where it is?

Mr. TRIMBLE. Yes. I can't find much wrong with the present size.

If anything, I would guess it is too large.

Mr. CHENOWETH. Too large now?

Mr. TRIMBLE. If something is not perfect, it has to be too small or too large.

If I had to pick whether too small or too large, I would pick too large.

Mr. CHENOWETH. We are spending large sums of money in this program. I think it is important we do practice economy wherever possible.

I again want to compliment you and the Martin Co. on your program and the fact that you have been able to save money.

We commend you on that effort. Happy to have you here. Thank you very much.

That is all, Mr. Chairman.

Mr. TRIMBLE. Thank you.

The CHAIRMAN. Have you any suggestions that the program is too large where we should curtail it?

Mr. TRIMBLE. No. When I answered that, I didn't have any specific program in mind, but if I look at the gross national product and where the Government spends all its moneys, there certainly is an awful large piece of it going into space.

I am certainly not competent to judge how that ought to be split up for our economy, because I only know one part of it.

However, I would expect myself, you see, to be favorable toward the space things, because that is the business I am in. So, I therefore, tend to react this way.

The CHAIRMAN. You lean over backward.

Mr. TRIMBLE. I try to. I don't know whether I make it.

The CHAIRMAN. Well, I don't know. I am very happy to hear you say that you think we are making progress.

Personally, I have never felt we are in competition in this field with anybody.

Our objective is peaceful exploration of outer space and to see how it can benefit mankind.

This is what we are after. We don't want to be too parsimonious. Pretty hard to find the medium we are after.

I want to congratulate both you and Dr. Ross and the others who have appeared here.

In my own view, it is very good to ask you gentlemen to come here to talk to you occasionally. It gives us another slant.

I think Mr. Truax mentioned the fact that maybe we look too closely—NASA looks too closely—at some of the contracts; this can be overdone.

Do you subscribe to his theory on it?

Mr. TRIMBLE. Sometimes it is overdone, and sometimes it isn't, and in general, I think it is the function of the individuals that are involved.

In a program as large as the space program, it is clear that the Government has to manage it.

Now to the extent and detail that Government manages it, the Government has to decide.

If they are the manager, they have to decide. I suspect there are areas where the Government hasn't delegated enough authority, just as on occasion in our company where we haven't delegated enough.

So I suspect I have got to give you the yes-no answer because I know particular areas we think we are watched too closely and I know some areas where we don't think we are watched closely enough.

The CHAIRMAN. When he was talking, I had in mind a very early experience as a young man, when I was a timekeeper, hired as a timekeeper on some railroad construction.

We had an extra gang of about 500 people and I had to keep time on them. I knew all of the answers to these things, so I came up with the scheme where I could check—we had to watch very carefully they did not switch buttons, these fellows had to show a number, one fellow would put on his own button and slip down to another place and put on somebody else's button.

I devised a scheme that was foolproof, it would only take about 10 minutes a day for each of these people. I laid this out. A lot of smiles. The engineer in charge let me go on and tell all about this and then when I got through he said, "We are hiring you to keep time on these people, there are 500 people, it would be 5,000 minutes, 200 days' work, you get out there and do it, without taking up their time."

I am just wondering whether maybe sometimes in Government—I have been in administrative Government and I know what happens—we are so interested in saving money that we do not overdo it and actually spend money.

We know in the 5- and 10-cent stores they have a certain amount of pilferage. It is less than 5 percent.

They could stop it completely but it would cost 10 percent to stop it.

Mr. TRIMBLE. True.

The CHAIRMAN. Mr. Waggonner?

Mr. WAGGONNER. I had one question which might go back a little bit to something that Mr. Ross and Mr. Truax had to say—you talk about orbital basing, something out there. I look on it as one of the necessary things that we have to do.

Can you relate orbital basing to what Mr. Truax had to say about what appeared at one time to be a firm Nova trend which is now soft and not so firm, or is orbital related to the present softness or lack of direction of the Nova program?

Mr. TRIMBLE. I really don't know. I don't know enough about why the change in Nova.

The CHAIRMAN. Is orbital basing going to reduce the requirement earlier for bigger engines?

Can we help solve the problem of bigger engines by orbital basing now?

Mr. TRIMBLE. I think with orbital basing we would still need larger engines that anybody is willing to dream about at the moment.

The CHAIRMAN. Mr. Morris?

Mr. MORRIS. Mr. Trimble, as I interpret your statement, you indicate that on the basis of what knowledge we have at the present time, or what studies your company has conducted, there could be considerable savings in the overall space program by the recovery of boosters?

Mr. TRIMBLE. Yes.

Mr. MORRIS. And we actually do not have a program going in this at the present time that I know of.

Do you know of any program that is underway in this field?

Mr. TRIMBLE. No hardware program.

Mr. MORRIS. Are there any research and development programs financed purely by the Government that you know of?

Mr. TRIMBLE. None that I know of.

Mr. MORRIS. Thank you.

The CHAIRMAN. Mr. Corman.

Mr. CORMAN. Can you suggest any changes in the relationship between the Government and the contractors that would add to the incentive for making dollar savings?

Mr. TRIMBLE. The best one I have heard of lately is the incentive contract approach that has been taken by the Government, and we like this—I think it is a good idea.

Mr. CORMAN. That holds real promise.

Mr. TRIMBLE. I think so. We have been into it quite a bit. It looks like it might get a bit sticky to work out in spots, but I think it holds a lot of promise.

Mr. CORMAN. Mr. Fulton?

Mr. FULTON. Can you tell us how we can get greater reliability on the components that are in regular use on these boosters and engines?

How can we get greater reliability and higher technical standards?

Mr. TRIMBLE. On the ones that are now in use?

Mr. FULTON. My problem is this: On research and development items, of course, we are going to have failures. Our failures in the last 6 months seem to have been largely from engineering and manufacturing and reliability failures.

How do we get over that?

Mr. TRIMBLE. You mean human failures in engineering and manufacturing?

Mr. FULTON. Yes. It it the engineering and manufacturing that is causing the failures. The payloads have not had a chance to be used. What is it?

Do we need more standardization, more inspection, fewer booster models?

Mr. TRIMBLE. Well, standardization is certainly one way to get there. We do not have much trouble with bolts—although we occasionally do, even though they are standardized. I don't know how you eliminate human failure. You try to keep people motivated as highly as possible so as not to make mistakes, yet people being people, they do.

Mr. FULTON. If we are going to keep up to the Russians, we must be able to launch on time and exactly on target?

Mr. TRIMBLE. I think we can do that now.

Mr. FULTON. I have been to a good many shots at Cape Canaveral and I have always been amazed at the number of holds. I have just heard that the Mariner second shot for Venus has been scratched completely this week and postponed to next week.

Mr. TRIMBLE. Of course, I don't know of the details of those programs, sir, but in our case, in the Titan I, I believe we have launched without a hold on many of the missiles in the services as we got toward the end of the development program.

We had some holds because of things not to do with the missile, like ship on the range, or something like that.

But I do not think it is very difficult to fire within a few seconds of when you want to fire right now with some of the equipment.

Maybe the programs you are mentioning are new and the machinery has not been exercised before. I would not expect us, for example, to be able to fire Titan II on time because we have only just begun to work it.

Mr. FULTON. Rather than comment on a specific program, don't you think the U.S. space industry is to the point where it is of sufficient competency that there should be rigid standards of reliability and warranties should be set on regular components that are used many times?

Mr. TRIMBLE. Yes, I do.

The CHAIRMAN. Should we have a society of automotive engineers that establish standards?

Mr. TRIMBLE. I think that is already underway.

The CHAIRMAN. It is not in effect, is it, it is just more or less going into effect?

Mr. TRIMBLE. It is awfully early in the missile or rocket business to standardize and you can standardize too soon.

The CHAIRMAN. That is right.

Mr. TRIMBLE. The environment keeps changing too. People sometimes lose track of this. I mean the physical environment changes.

For example, on a Titan, whether it is going to shoot military payload, ballistic missile payload, or go into orbit.

Machinery has a different environment under the two cases. Everything in Titan has been qualified for the case of the ICBM. This does not necessarily mean those parts which could now be called standard for ICBM mission would be all right for the other missions.

The CHAIRMAN. Thank you very much, gentlemen.

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We appreciate your coming here. We thank you again for your willingness to return after we had to reschedule your appearance. I apologize that we had to hold you over so long, but you made a very fine contribution. We will be calling on you again one of these days.

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

The CHAIRMAN. We stand adjourned until 10 o'clock tomorrow morning.

(Whereupon, at 12:10 p.m., the committee was adjourned, to reconvene at 10 a.m., Friday, August 17, 1962.)

APPENDIXES

Appendix A

Aerojet-General Corp.,
Azusa, Calif.

Subject: Aerojet-General Report No. 2353.

Frank R. Hammill, Jr.,
Counsel, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

Dear Mr. Hammill: We are forwarding for your information an advance copy of the subject report entitled "The U. S. A. Space Program—Costs and Cost Reductions."

Additional copies will be forwarded as soon as they are completed.

Sincerely yours,

R. D. Waldo,
Manager, Operations Research Department.

THE U. S. A. SPACE PROGRAM

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COSTS AND COST REDUCTIONS

Prepared by:

Corporate Operations Research Department
Aerojet-General Corporation
Azusa, California

Aerojet Report No. 2353
August, 1962

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INTRODUCTION

The U. S. space program of the next three decades was postulated for the purpose of examining its costs and where cost reductions might be realized. This report presents a summary of gross cost data of two of the elements of the space program. These elements, boosters and space transport vehicles, constitute two major cost items both in the research and development and also the operational phases.

Throughout this report a two-phase flight operation is presumed - that is, a boost phase, which is from earth surface to low earth orbit, and the space transport phase, which is from earth orbit to destination and return. Introduced into the results of the study are the forecasted effects to be realized from advanced technology developments. The resultant schedules are based upon current state of national urgency in military and space exploration affairs and the associated funding levels.

TWO AREAS OF U.S.A. SPACE PROGRAM WHERE SAVINGS MAY BE REALIZED

1. BOOSTERS

2. SPACE TRANSPORT VEHICLES

Figure 1

BOOSTERS

To permit an adequate consideration of booster costs and cost reduction it is necessary to consider the very important aspects of recoverability and refurbishment.

Note: Cost data are based on vehicle costs per launch costs (no amortization of fixed costs).

EXAMPLES OF BOOSTER RESEARCH & DEVELOPMENT COSTS

1. SATURN C-5: 2 TO 2 1/2 BIL.
INCLUDING ENGINES

2. RIFT-NERVA: 1 1/2 TO 2 BIL.

3. AEROSPACEPLANE: 5 TO 7 BIL.
INCLUDING ENGINES

Figure 2 presents by examples an indication of the magnitude of the research and development costs of boosters for the space program. Program savings are to be realized, of course, through committing to research and development only those boosters required by the program. Savings are also to be obtained through booster recovery and by the reduction of refurbishment of the recovered boosters, even though these additions increase the research and development costs.

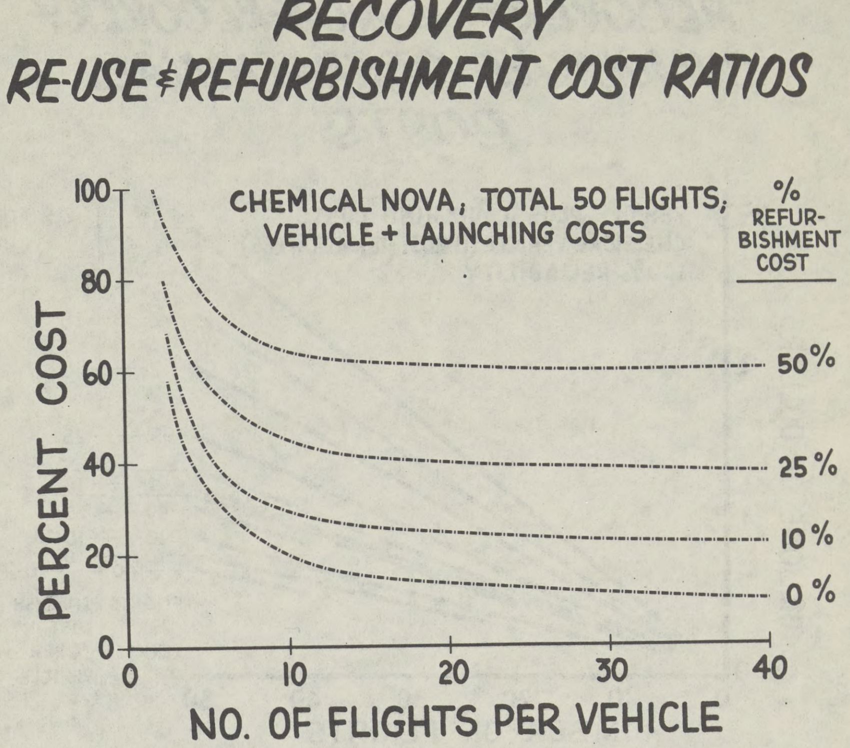

Figure 3 presents in general terms the effect of two major recoverability parameters on the reduced cost fraction for a recoverable NOVA versus a non-recoverable NOVA. The significant parameters are the number of flights obtained per vehicle and the refurbishment costs required to prepare the vehicle for a new flight. Another parameter to be observed is that after approximately ten flights per vehicle recovery ceases to be as significant in the reduction of booster costs and launching costs increase in importance. Studies reveal the same parameter exists for other types of boosters.

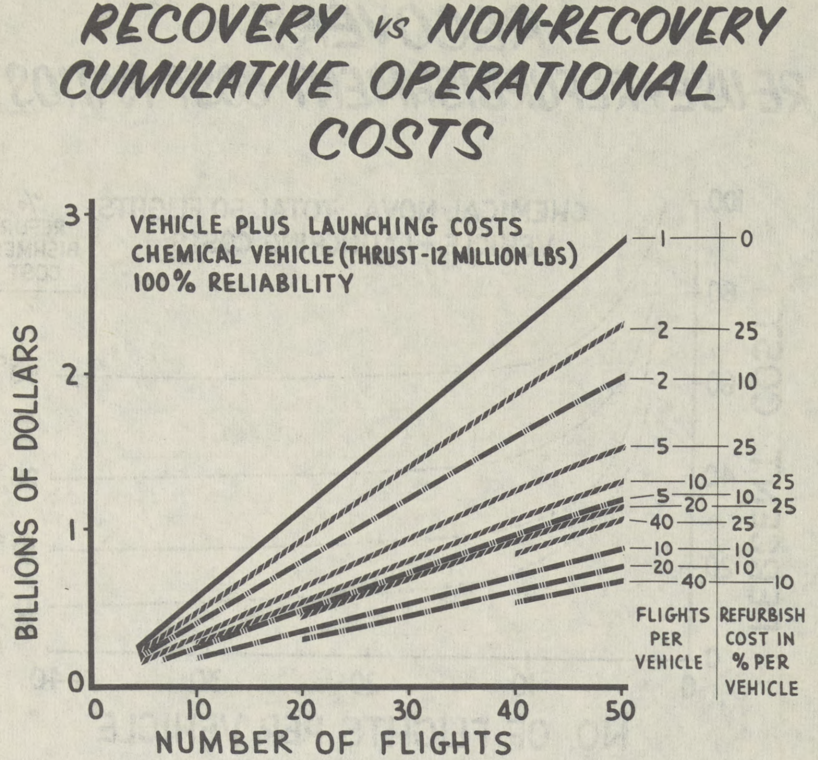

Figure 4 indicates cumulative booster operational costs, vehicle plus launching costs, for non-recovery and also for a large number of recovered conditions of a NOVA chemical booster. The various lines on this chart represent the parameters of the number of flights obtained per vehicle and, associated with this, a given refurbishment cost as a per cent. The data for other boosters would be similar in nature.

For example, the second line down from the top indicates a total of two flights per vehicle with a cost of 25% of vehicle cost for refurbishment to prepare for the second flight after recovery. The top line of one flight with no refurbishment cost represents the limiting condition of no recovery.

Thus it is possible to compare the savings to be realized from recovery against such fixed costs as research and development costs.

In order to gain further insight into booster economies it is necessary to consider the various elements of the space program affecting the scale of operations in space. Figures 5 through 10 present forecasts of data considered pertinent to this further analysis.

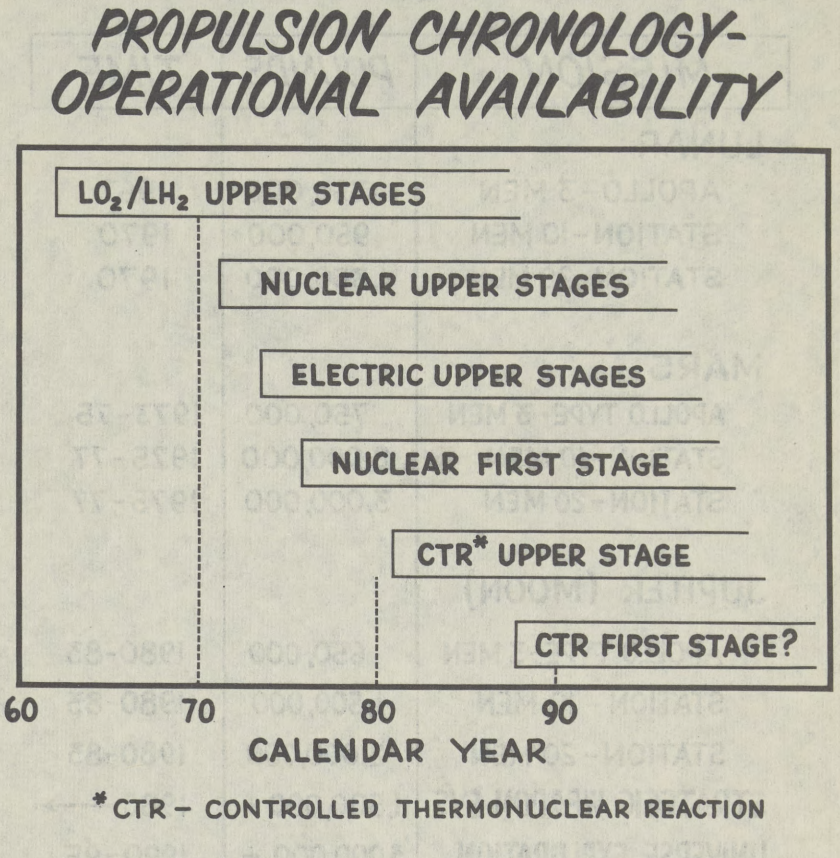

Figure 5 indicates the dates of operational availability of selected space propulsion engines. It is to be noted that these would not constitute first flight dates, but rather true operational availability.

SPACE MISSIONS
WEIGHT REQUIRED IN 300-MI. EARTH ORBIT

(INCLUDES: PROPULSION, FERRY RETURN, ESCAPE VEHICLE, MANNED STATION AND EQUIPMENT)

MISSION	POUNDS	TIME
LUNAR:		
APOLLO-3 MEN	350,000	1967
STATION-10 MEN	950,000	1970
STATION-20 MEN	1,350,000	1970
MARS:		
APOLLO TYPE-3 MEN	750,000	1973-75
STATION-10 MEN	2,000,000	1975-77
STATION-20 MEN	3,000,000	1975-77
JUPITER (MOON)		
APOLLO TYPE-3 MEN	650,000	1980-83
STATION - 10 MEN	1,500,000	1980-83
STATION-20 MEN	2,000,000	1980-83
STRATEGIC WEAPON SYS	1,500,000 +	1980 ⟶
UNIVERSE EXPLORATION	3,000,000 +	1990-95

Figure 6 combines a selected list of space mission options with the possible earliest times for achievement of these operations. Also indicated is the payload or the initial gross weight required in orbit to achieve the listed mission. Implicit in these data are the use of the best space propulsion engines available in that time period as indicated in Figure 5.

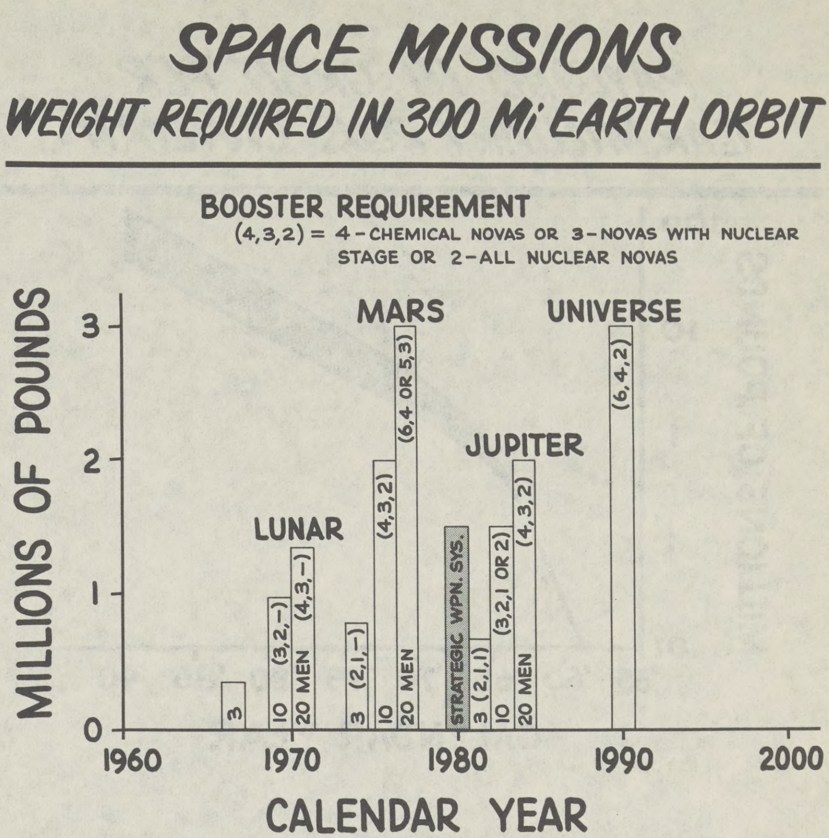

Figure 7 presents in bar chart form the data contained in Figure 6. Again it is noted that the flight operational modes assume a boost phase to low orbit and then the suitable space engine takes over for the space flight. Indicated in the parenthesis within the bars are quantities of NOVA sized boosters required to boost the required payload into low orbit. The three numbers shown indicate in order the use of a two-stage all-chemical NOVA, a chemical NOVA first stage with a nuclear second stage, or an all-nuclear NOVA vehicle. Thus reductions in the necessary numbers of boost launches is indicated as advancements in technology are employed, and implicit are the reductions in the total weight boosted off the earth as these advancements are employed.

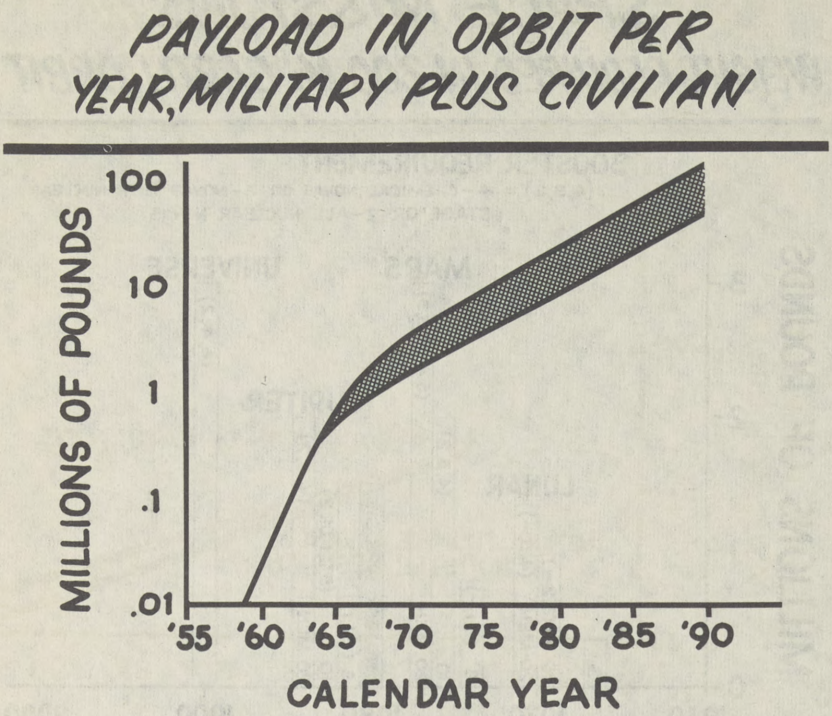

Figure 8 presents an estimate of the extent of payload (military plus civilian) that will be placed in orbit per year during the next three decades. Taken into consideration in the development of the estimates are the operational availability of propulsion systems allowing for advancements in the state-of-the-art.

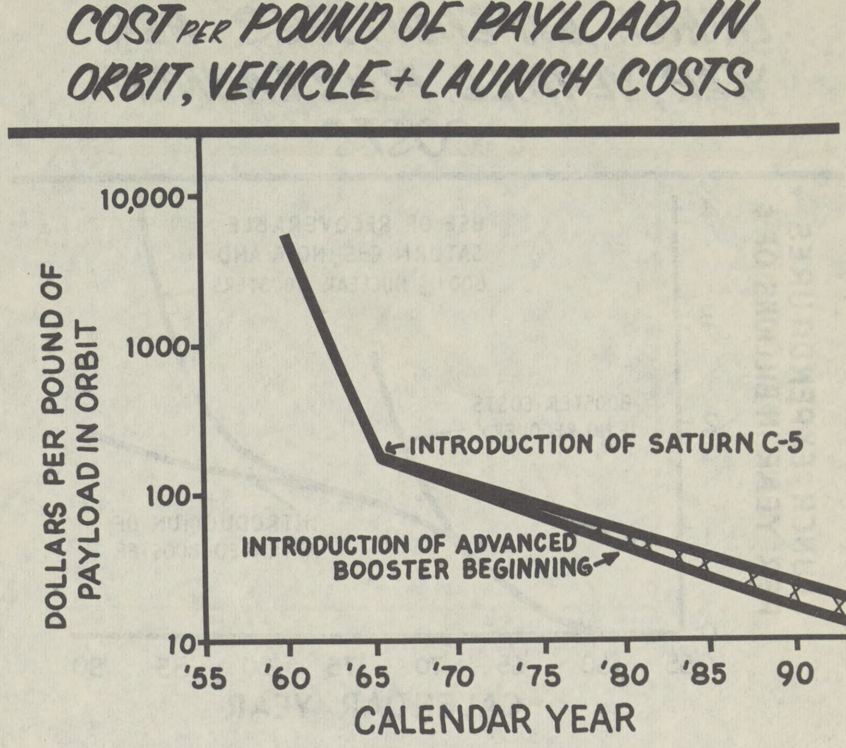

Figure 9 presents an estimate of the cost per pound of placing payload in orbit. Included in the cost are the vehicle and launch costs. Allowed for are the effects of booster recovery and refurbishment, as well as the improvements in propulsion technology as they are estimated to become available.

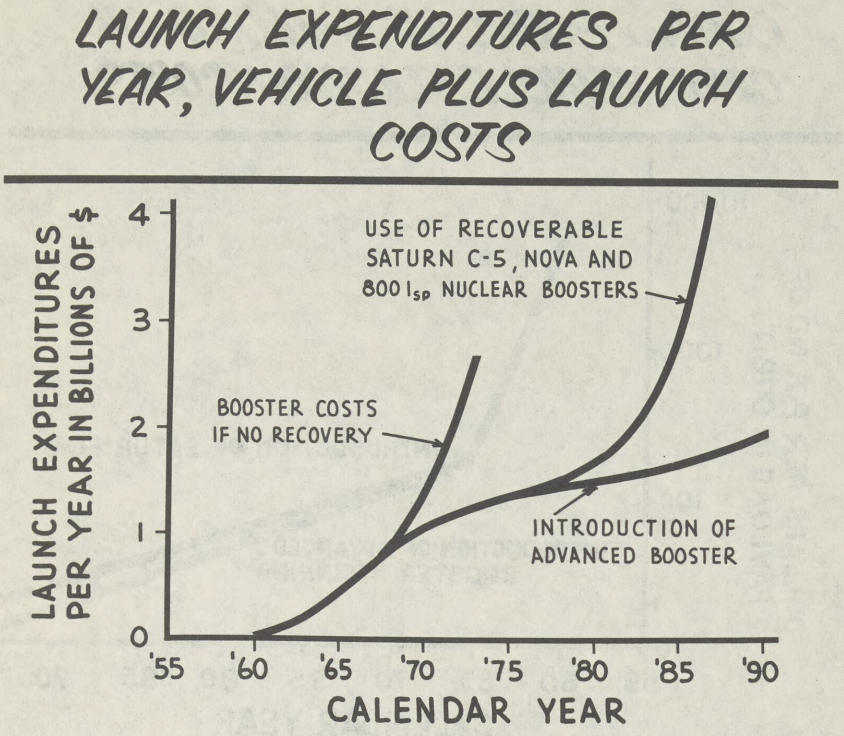

Figure 10 indicates the amount of expenditures for the booster vehicle and the launching costs per year that will be required to place the estimated payloads of the U. S. space program in orbit. Also shown are the effects on expenditures if booster recovery and reduced refurbishment are not achieved. For the time period beyond 1975 the need for a significant advancement in booster technology is indicated. An advanced booster, yielding the lower line, is required to prevent an otherwise rapid rise in expenditure rate in the early 1980's. Smooth fairings between the curves are used to suggest the transition and learning which will take place.

SPACE TRANSPORT

VEHICLES

The next three charts present a summary of the costs in dollars per pound of payload to propel a payload to various total velocities using four different space engines.

Note: As for the recovery data the costs presented include only vehicle costs and launch costs.

COMPARATIVE COSTS - NO RECOVERY

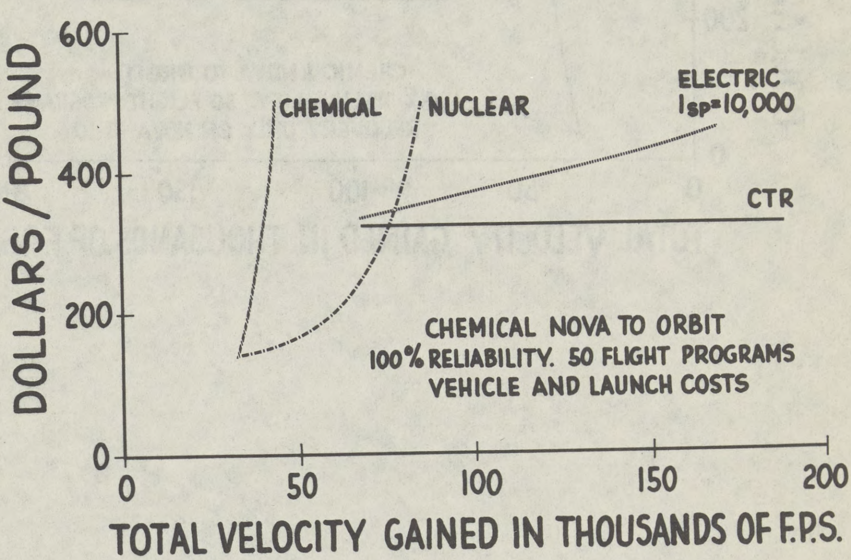

Figure 11 indicates the costs that would exist with a NOVA booster and no recoverability.

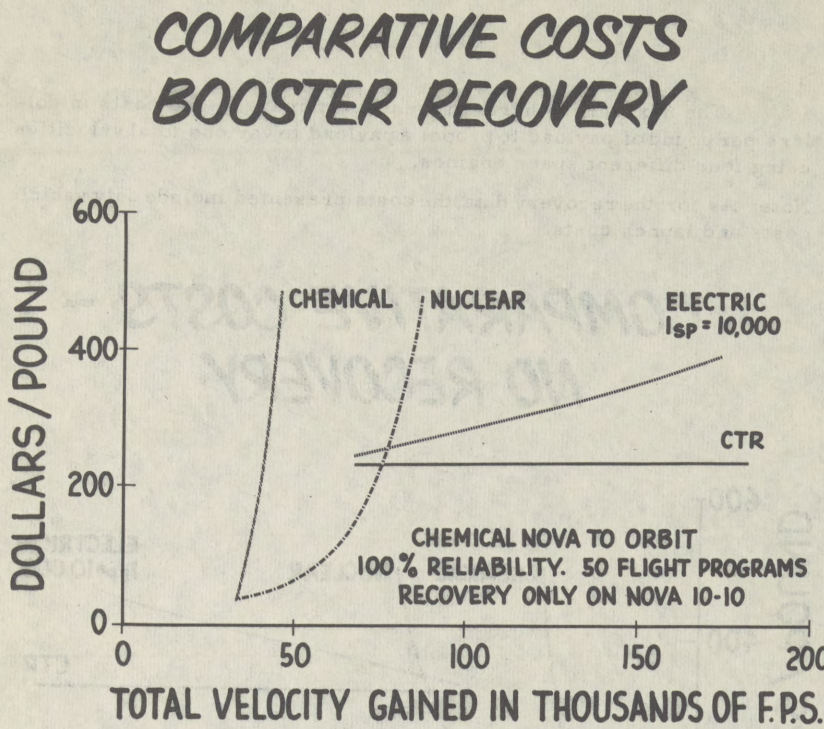

Figure 12 indicates the cost with a recoverable NOVA booster but no recovery for the space stages.

COMPARATIVE COSTS
BOOSTER & SPACE VEHICLE RECOVERY

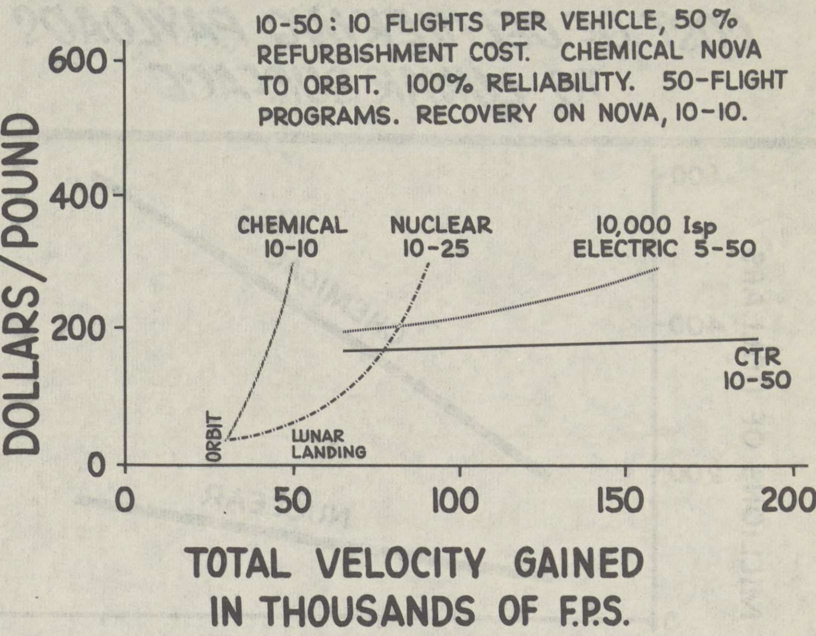

Figure 13 indicates the cost for full recoverability - that is, the booster is recoverable and the space vehicle containing the space engine is recoverable. It is noted that the most economical operating regimes of a given propulsion scheme are relatively unaltered by the use of the recovery, while the total cost in dollars per pound is very significantly influenced by the items of recovery. Development costs are not included in these data in order that the savings achieved can be balanced off against the development costs required.

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The following three figures show the cumulative costs of delivering payloads to the lunar surface, Mars, and to a Jupiter moon. The costs of the different space transport vehicles are given on a comparative basis so that savings realized by utilizing the most efficient system might be compared with estimated research and development costs.

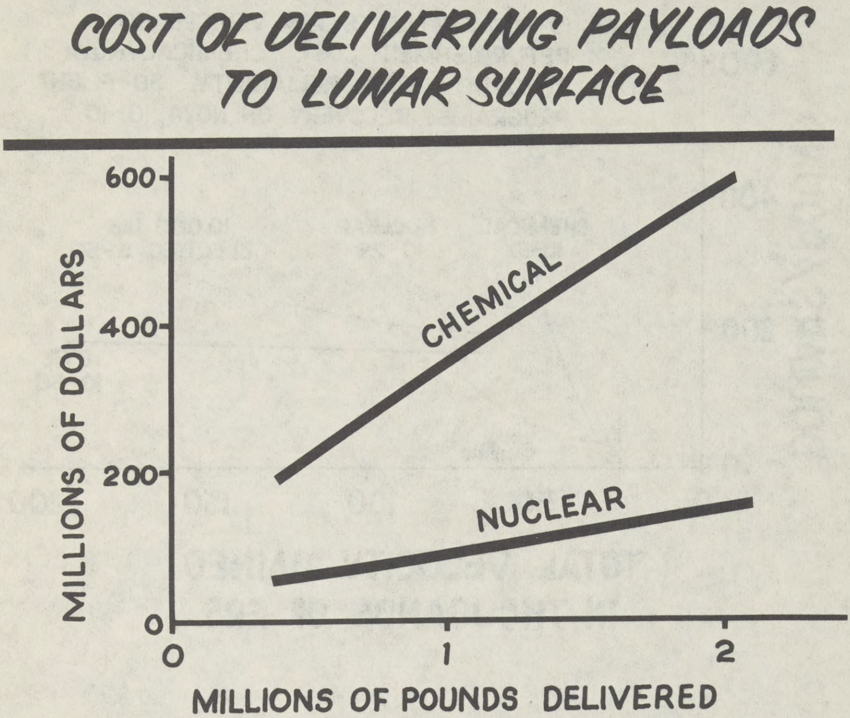

Figure 14 indicates the costs of delivering payloads to the lunar surface utilizing a chemical space transport vehicle as compared to one using nuclear propulsion.

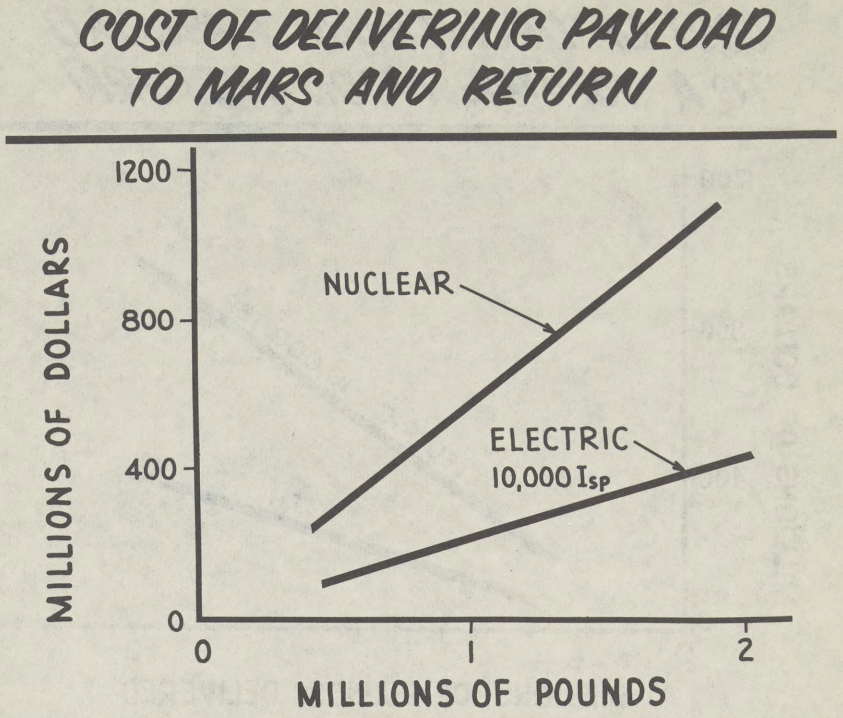

Figure 15 is a comparison of the costs of round trips to Mars employing nuclear transport vehicles and electric propulsion vehicles. Chemical vehicle costs are not indicated as the amount of their costs would make them non-competitive.

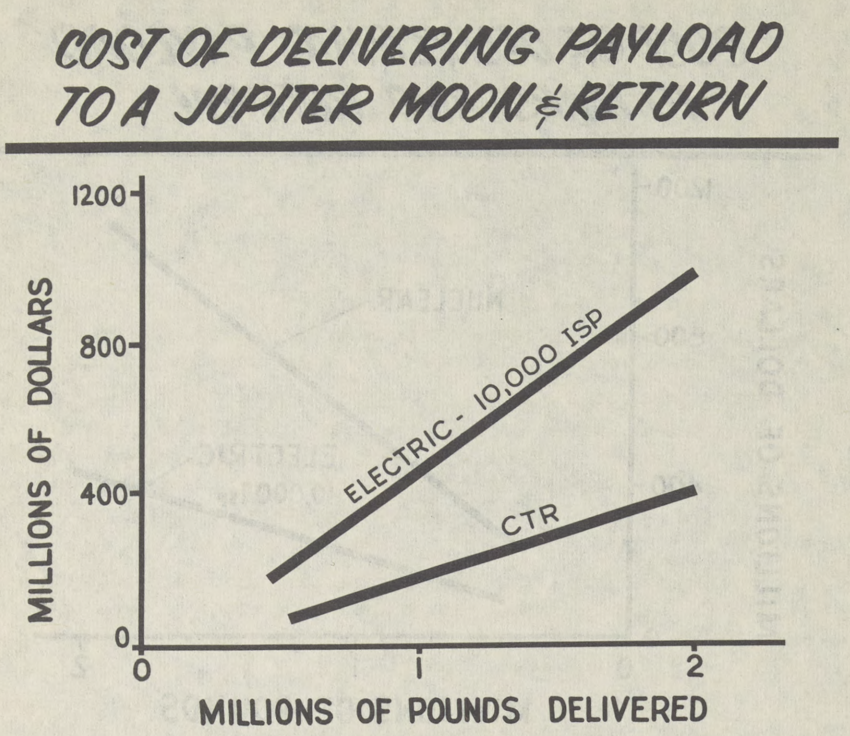

Figure 16 presents the costs involved in delivering payloads beyond Mars, such as to the vicinity of Jupiter.

CONCLUSIONS

1. As the tempo of the U. S. space program increases there will be a definite economic justification for the research and development of an improved booster based upon advancements in the state-of-the-art.

2. Recovery and reduction in refurbishment for boosters and space transport vehicles has definite economic justification consistent with technological capability.

3. The development of advanced space transport propulsion systems is required from both the standpoint of making space exploration and utilization feasible, and also from an economic justification.

4. Space nuclear rocket propulsion is the most economical system for employment in the velocity range from orbital to about 80,000 feet per second. This range encompasses round trips (orbit-to-orbit-to-orbit) to the moon and a large range of transfers to Mars or Venus orbits. A very limited range of round trips to Mars and Venus is also included.

5. In the 1970 time period electrical propulsion provides the best system for space propulsion for manned trips to Mars or Venus and on to the vicinity of Jupiter; operations requiring total velocities of 100,000 to 150,000 feet per second.

6. When available, a controlled thermonuclear reaction propulsion scheme is the most economically desirable method for the deep space operations requiring velocities above about 80,000 feet per second. It also is a required system for man to actually "fly" under continuous power in space with adequate options of course changes.

7. An earth orbital rendezvous technique is required, and with this capability there is a reasonable upper limit on the size of launch booster vehicle required, regardless of whether it be a chemical or nuclear booster.

8. Failure to achieve booster and reduce refurbishment costs would constitute a limiting factor upon the U. S. space program. In similar fashion, the failure to develop and bring to operational use an advanced booster with considerable improvement in payload to orbit capability, as compared to Saturn C-5, NOVA, and an 800 I_{sp} nuclear booster, would constitute a limiting factor on the nation's space program beginning in the last half of the 1970's.

APPENDIX B

UNITED TECHNOLOGY CORP.,
Sunnyvale, Calif., August 14, 1962.

COMMITTEE ON SCIENCE AND ASTRONAUTICS,
House of Representatives,
Washington, D.C.

(Attention: Mr. Charles F. Ducander, Executive Director and Chief Counsel.)

GENTLEMEN: The magnitude of the U.S. space effort is almost overwhelming in terms of cost and its impact upon the Nation's resources and scientific manpower. The major increase in the current space budget as approved by Congress and budget projections over the next 10 years clearly indicate that the exploration of space for both peaceful and military applications is and will continue to be an important part of the Federal budget and our Nation's economy. As the leading nation of the free world the United States must play a leading role in space; however, we cannot and should not do this to the detriment of our other national institutions and objectives.

The Science and Astronautics Committee's current study into the economics of the U.S. space program and potential ways of effecting savings in the program is particularly appropriate at this point in time. Our major space projects are just beginning to expand at an accelerated pace and we can reflect on our past missile and space efforts to determine our failings. United Technology Corp. appreciates the opportunity to take part in the committee's study and we have approached the problem area of economy in our space program with sincerity and objectivity.

Probably the most significant area to be considered in terms of reducing the overall cost of the U.S. space program is the reliability of components, subsystems, launch vehicles, and payloads. It must be remembered that space missions will always require highly complex and costly vehicles and support equipment. Furthermore, the limited number of missions will preclude the potential cost savings of mass production. Therefore, we must look toward the most effective utilization of each launch vehicle and payload.

A number of our past flight tests have resulted in partial or complete failure of the launch vehicle or payload so that little useful data were obtained from the particular test. The necessity of repeating these tests has significantly increased the overall cost of our space program to date. If the reliability of these systems could be significantly increased the incidence of flight failures would materially decrease and the added costs associated with repeating flight tests would be eliminated.

Reliability must start with proper design of components, subsystems, and complete flight systems. In turn, proper quality control must be maintained during fabrication, assembly, and checkout. In addition the data obtained from repeated flight usage add to our knowledge of the reliability of particular components, subsystems, and entire flight systems. It therefore appears that repeated use of components, subsystems, and entire flight systems which have proven reliability is desirable.

The past approach of a special launch vehicle for each new mission should be minimized. We should strive for a family of launch vehicles which may be utilized for a wide variety of missions and payloads. This approach has recently been initiated as can be seen in the universal concepts proposed for Agena and the 624A program (Titan III). This universal concept should be encouraged wherever possible.

Another area of potential cost effectiveness is the minimizing of costs during the research and development phase. Historically, R. & D. programs have been conducted under cost plus a fixed fee (CPFF) contracts. Although most contractors are sincere and try to do the best job for the Government at minimum costs, the CPFF contract does not encourage cost savings. The utilization of incentive type cost contracts and possibly fixed price contracts during the R. & D. phase of a program does not appear unreasonable. Each program should be considered on its own merit as to definitions, complexity, and probability of success. In turn, the most effective contractual vehicle should be selected.

In connection with the utilization of incentive type contracts for R. & D. programs, a system of rewards and penalties should be instituted which would significantly reward those contractors who perform in an outstanding manner and who risk substantial funds of their own for facilities and other capital equipment items and in turn would significantly penalize those contractors who fail to perform. The incentive approach must be a "two-way street." Most current incentive plans emphasize the penalty aspect for poor performance. The primary objective of incentive type contracts should be to foster cost and performance effectiveness in R. & D. programs.

There are several other areas which are related to the economic aspects of the U.S. space program; however, most of these have been covered in great detail by the various witnesses which have appeared before your committee.

Therefore, in concluding we would like to reiterate the concept that the exploration of space on a massive scale is inherently an expensive venture. One means to cost effectiveness in the U.S. space program is the concept of a limited number of highly reliable systems to perform a wide range of space missions.

Very truly yours,

BARNET R. ADELMAN,
Executive Vice President.

APPENDIX C

DOUGLAS AIRCRAFT CO., INC.,
Santa Monica, Calif., August 17, 1962.

MR. CHARLES F. DUCANDER,
Executive Director and Chief Counsel,
Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. DUCANDER: I am responding to your letter on behalf of the Committee on Science and Astronautics for comments of the Douglas Aircraft Co. on possibilities for effecting savings in the national space program.

You will find enclosed a summary of our thinking on this timely and important subject which has such a great bearing on the ability of our Nation to maintain its international leadership in scientific development while at the same time remaining within the bounds of a prudent fiscal policy.

We appreciate this opportunity to present our views and we are hopeful that they will be of some service in accomplishing the objectives of your study.

Sincerely,

DONALD W. DOUGLAS, Jr.

AREAS OF POTENTIAL SAVINGS IN THE NATIONAL SPACE PROGRAM

SECTION I. TECHNICAL AREAS

In response to this inquiry, we wish to clarify our point of view on potential economies by observing that much of the expenditures required to support the national space program for the next 5 years are fairly well obligated by program decisions which have already been made. For these programs, it is felt that large economies cannot be effected other than by careful management and frequent reappraisal of major decisions applying to each program, as for example, in the major elements of the Apollo program.

It must be recognized that future economies must be calculated on the total space program and that extreme caution must always be exercised concerning the possibility that a dollar savings in one element of one system, or in one system in relation to others required, may in fact result in large increase in cost for the total space program.

We conclude therefore that the committee can benefit best by suggestions of those means whereby space systems beyond Apollo can be made as economical as possible. In our exposition of this thesis we do not intend, however, to exclude those developments already underway, since we recognize that future space programs will only be economical in the degree to which they utilize the actual hardware systems, facilities, and national experience which will result from presently programed systems such as Apollo.

Mission objectives

It is considered fundamental that the national space program, beyond its early development phases, will only be considered economical when the cost can be tested against accepted national goals in space. To the degree that national objectives in space are still somewhat vague, it is considered imperative that much effort should be devoted promptly to the definition of long-term objectives of the space program so that a measure of economies can be made against these.

It is believed that large savings in the future space program can be achieved by deciding the objectives early and building systems which can accommodate those objectives through flexibility. This is differentiated from our early space efforts where many versions of spacecraft payloads had to be built to accommodate the severe payload limitations of boosters, and where the booster capabilities changed by orders of magnitude within the first decade of the space age. It is felt that we must avoid the pitfall of attempting to optimize individual spacecraft to achieve very specialized missions, when the addition of a modest amount of flexibility in that spacecraft will allow it to perform many missions.

As mentioned by the committee, such advances as reusable launch vehicles and automatic checkout equipment are typical of the means whereby technology advances can justify new systems development on the basis of their resultant savings to the total space program. A word of caution might be introduced here, however. Referring again to the need for defining the national objectives in space, there could result many false economies if some of these advanced technological concepts were developed without having a really serious intent of employing them at the pace where operational economies could overcome development costs.

Development philosophy

With present space programs the cost of developing the hardware has become a very large percentage of the total systems cost. As we move on to a space program which could be classed as operational, system development costs will continue to increase beyond their present level. Within given program elements of the total space program package, however, there will be many cases where the production costs and operational costs of a large number of space vehicles or global communication networks result in many new and different opportunities for economizing.

For example, at the present time the acquisition of data fed back from a spacecraft, or the guidance or tracking of space vehicles, is achieved almost exclusively with a development type instrumentation network. Almost every vehicle or payload development that comes along requires very specialized modifications for its tracking and data handling. Frequently, the true demands of the development program make this special treatment very worthwhile to the overall economy. In the future, however, such ground support systems will certainly have to be made adaptable to large traffic handling capabilities of an operational space age, in the same context that the FAA has found it a basic necessity to have an integrated traffic control system.

The above example illustrates what will become an increasing requirement in future space programs. Each element of the total system must be developed in terms of its individual cost, as well as in terms of its ability to support system operations. By applying this development philosophy to all system elements—from design and production, through instrumentation and testing, to logistic support of an operational system—maximum program economies can be realized.

Design philosophy

In the design and development of military, as well as commercial aircraft, there has been a natural recognition of the preeminence of safety and survivability provisions for the passengers and crew. In many new aircraft, complex safety subsystems have been integrated into the vehicle design from its inception. As we learned from testing and reliability demonstrations how to accommodate to the operational environment, however, such subsystems lost their preeminence in design considerations in favor of an integrated systems approach which would provide for survivability of the entire vehicle.

It is agreed that during the first generation of manned space vehicles such as Mercury, Gemini, and Apollo, we have good cause to make preeminent those subsystem designs which will provide the highest assurance of crew survivability and recovery. As we proceed toward an operational space era, however, it is considered important that we design primarily for total vehicle survivability.

This design philosophy becomes heavily involved in the economics of the space program. Cost considerations dictate that we avoid the pitfalls of becoming so overwhelmed by safety problems, or other subsystem considerations, that we allow unnecessary redundancies to dominate vehicle design.

Standardization of system components must also be accepted as a design objective. It is recognized that recent space development programs have been quite expensive in part because each system or vehicle was developed with the use of especially designed components, many of which were still in early development themselves. In the areas of telemetry and communications equipment, computer techniques, guidance equipment, ground-based checkout systems, cryogenic pumps and valves, hydraulic and pneumatic systems, and a multitude of common mechanical and electrical components, almost complete customizing of every component has been required in order to get the maximum performance from the total system.

We submit that there are many components that still require extensive development before they truly can be classified as operational. We still need development experiments in space to ascertain true operational environments and to determine reliability requirements. On the other hand, we believe there are many elements of space vehicles and certainly many elements of ground systems which have already approached their most effective level of operation.

For the operational space era, which we assume is of concern to the committee, it is felt we cannot afford to continue customizing each and every subsystem and equipment item. Certainly it can be expected that in future space systems all common system elements can be standardized. This is of utmost importance to both system reliability and cost.

SECTION II. MANAGEMENT AREAS

Our discussions on the management aspects of the national space program will be limited to those Government-to-industry relationships wherein we see possibilities of savings through change or refinement of existing management methods or through the introduction of new management concepts.

In regard to broad principles, management can be considered as somewhat comparable to politics, since each is recognized as an art. Politics is also recognized as a science, but management is still struggling to attain that stature. This comparison serves to illustrate the cause of some of our most critical management problems—confusion and overemphasis in the application of organizational, as opposed to directional or control activities. It is in this area we forecast that the greatest system savings can be obtained.

Management tools

As an example of the value of new management tools, it is believed the national space program can realize measured savings by increased use of new control techniques such as PERT and PERT/cost. Certainly as both industry and Government become more accustomed to using these tools for sophisticated development programs it should be very effective to use them even more intimately in the operational phases of space programs. It is predicted that we will find means of using such scheduling and cost review techniques in operational programs to keep tight control of space supplies, vehicle utilization, manpower loadings, and traffic logistics. The key point to these sources of savings is we are finding effective tools with which to handle complex programs quantitatively. This new art is bound to improve significantly and may be expected to receive credit for significant savings.

An additional management technique which can be expected to effect large savings is that related to the program package definition, including program planning and cost effectiveness, which is presently being utilized by the Department of Defense. By integrating planning with complete program packaging, including the development of the primary hardware components as well as their logistics, training, and field support, it becomes possible to recognize the management aspects of a total system. By so recognizing the total program package requirement, there can be expected much more sound judgment of the overall merits of a new program measured in terms of its cost impact. Application of this discipline should result in very significant savings in the national space program.

Management structures

Much needs to be said about shortcomings in the purely physical aspects of management structures as well as about the type people available to man those structures. It is not enough to simply assign a body to a function as represented by a block on an organizational chart, and assume that the job will be done correctly. Specific skills are required to accomplish specific functions, and the matching of these two items is mandatory if we are to save time and effect cost savings. Unfortunately, we have found that the shortage of competent and experienced managers is even more critical than the shortages of scientists and engineers.

It is recognized that both Government management and industry management are continuously faced with this problem in spite of their recent emphasis on management training. There is a danger that both participants are in the process of overextending themselves by accepting more—and more complex—management structures without being able to man them adequately. If this trend is not reversed we can expect the following stereotypes of management structures to develop:

1. *Technical overmanagement.*—In this stereotype much of the management pyramid will consist of technical personnel rather than business or contract management personnel. They will view themselves as being responsible for the technical excellence of the program but will have no direct responsibilities for funds expended by contractors. This will lead to a philosophy that a program is judged by how few failures occur, rather than by success per dollar spent. Under this structure many small program changes can be ordered and put into effect by lower layers of management without adequate consideration of cost, summing up to large program expenditures.

2. *Management by protection.*—As a corollary, a philosophy will develop within technical management that it is a crime to make a mistake. This will force all elements of the pyramid to spend an inordinate amount of time protecting themselves (in essence most program changes instituted from lower management levels are for this reason), and this in turn will place horrendous documentation requirements upon contractors.

3. *Management by dispersion.*—A grand management pyramid overstaffed with contract managers, of course, requires a grand collection of contractors to manage. Under this stereotype each program is split between many geographically spread contractors which introduces many needless and costly interfaces and leads to many costly technical problems being resolved by each different contractor. Large companies wind up with pieces of many programs, making assessment of their performance in such a structure next to impossible.

4. *Management by debilitation.*—Again, a grand management pyramid overstaffed by procurement types would require a grand procurement procedure. Each and every major level of the pyramid must be convinced that a contractor is worthy before the decision can be made. In this stereotype it may be conservatively estimated that many millions of dollars would be wasted annually by prospective contractors in attempting to obtain business. Since this work is primarily accomplished by the contractor's best technical personnel, it is also a tremendous drain on the country's scarce technical talent.

In conclusion, and on a more positive note, we are optimistic that many of the potential problems relating to management of the space program can be forestalled by the very awareness of the situation demonstrated by your committee, by industry, and by the National Aeronautics and Space Administration. NASA, as a new agency, has shown a vigor and freshness of approach which indicates a capability of adapting to the continuing and shifting demands of the space program in an efficient manner. We believe it is important for this agency to maintain the flexibility it now has so that it can meet its developing problems without excessive restrictions on its methods of dealing with them, whether they be imposed internally or externally.

Appendix D

General Dynamics-Astronautics,
San Diego, Calif., July 30, 1962.

Hon. George P. Miller,
Chairman, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

Dear Mr. Chairman: By letter of July 11, 1962, Mr. C. F. Ducander has requested that I express my views for the record, recommending "possibilities which may exist for introducing savings into the national space program." I am happy to comment on this subject and to applaud the aims of your inquiries.

The following possibilities for economy in the national space program are listed roughly in the order of prospective savings. I want to preface my list by stating that I consider that the National Aeronautics and Space Administration and the Department of the Air Force are accomplishing a rapidly expanding space program at an exceptional level of economy in the circumstances. They are daily surmounting new problems not only of technology, but also of organization and management.

To the extent that new economies can be effected, they may be achieved through:

1. *Increased common utilization between civilian and military equipment and facilities.*—Although civilian and military requirements in equipment and facilities differ in significant details—notably in the higher threshold of reliability for manned operations normally required in the civilian systems and in the quicker reaction capabilities normally desired in military systems—the areas of overlap in capabilities and requirements are large. In many instances, it will prove more economical to alter or add to the capabilities of a primary civilian or military launch vehicle; for example, to permit use for both civilian and military purposes than to undertake parallel and special vehicle development.

2. *Further advances in program management and control techniques.*—Terms such as "management lag" and "management revolution" are heard frequently these days. Such terms reflect a growing awareness of severe management problems arising from the very magnitude and complexity of space program integrated development activities. Currently, the vigorous attacks which governmental agencies are making upon this problem are largely fragmented and separate. Efforts to accelerate and unify the development of new management techniques per se may pay off in significant program economies. In devising and applying new management techniques, care must be taken to maintain a proper "arm's length" relationship between Government agencies and their industrial contractors. Otherwise, there is a danger of diluting accountability for decisions and eroding industry's sense of clear responsibility for reducing costs, maintaining schedules and improving reliability.

3. *Limitations upon the variety of space launch vehicles developed.*—From the standpoint of overall space program economy, it is desirable to concentrate development efforts on a few vehicles differing by large increments in performance. In many instances, and inefficient as it may seem, it is more economical to use too large a vehicle to place a small payload in orbit than to develop a new vehicle for the purpose.

4. *More effective utilization of excess payload capacity available in missile and space launches.*—With appropriate planning, it should be possible to arrange for and accomplish flights of auxiliary payloads to exploit excess payload capacity in missile and space launches without interfering with primary flight test schedules and objectives. I foresee that with larger and larger boosters a great deal of excess payload capacity will be available during test and operational programs. The nation's space science and space technology efforts can be advanced economically by existing technical coordination agencies through a serious, planned endeavor to exploit this excess capacity.

5. *Early definition of preferred design approaches to recoverable booster system development.*—It is likely that recoverable booster systems will prove more economical than expendable booster systems for some classes of payloads over the long run. In order to achieve recoverable boosters by the time they are needed, and to avert wasteful excursions into various recoverable booster development cul-de-sacs, civilian and military space science agencies should sponsor an early aggressive program of recoverable booster system and design comparisons, and select a preferred avenue for recoverable booster development.

6. *Better conservation of organization "learning" for transfer to new programs.*—During the last quarter of a major development program, the organization which has been assembled to conduct the program may be twice as productive as during its first quarter, for a variety of reasons usually summarized as "learning." Yet, in many instances, a contractor organization must be disassembled at the end of a program to an extent which destroys this learning. In due course, through the same or another contractor, the taxpayer must again pay to assemble and grow an organization through a learning cycle for a basically similar program. It is possible that Government agencies can conserve proven, integrated contractor learning through more prudent planning and phasing of programs, without impairing the legal and traditional conditions of competitive bidding.

We are pleased to have been asked to comment and hope that the above statements will be of value to you and your committee.

Very truly yours,

J. R. DEMPSEY, *President.*

APPENDIX E

LOCKHEED AIRCRAFT CORP.,
August 3, 1962.

Hon. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN MILLER: Lockheed Aircraft Corp. appreciates the opportunity extended by Mr. Charles F. Ducander, executive director and chief counsel of your committee, to propose methods to minimize costs associated with the Nation's space program. We are wholeheartedly behind your efforts to introduce savings in the program and hope that the suggestions and comments we are offering will make a contribution.

Lockheed has been privileged to participate in the national space program extensively through contracts awarded by both the Department of Defense and the National Aeronautics and Space Administration. This experience has led us to believe that two principal aspects of space programs have a direct bearing upon costs and offer the most likely areas of savings. These are the management and the technological base of a program.

We are convinced that the management element of a space program is of predominant influence on costs. The thousands of personnel required for conduct of a major space program must be effectively organized, directed, and controlled if we are to obtain maximum return for dollars spent. These technologically complex and tightly scheduled programs demand the most advanced management tools. And sound and experienced management judgment must be applied in a timely fashion at all levels of the decisionmaking process.

Sound management principles, of course, are well understood and recognized, and Government and industry must seek constantly to improve their application to the space program. An unusually good example of the proper application of these principles, we believe, is to be found in the development under Department of Defense direction of the standardized Agena space vehicle.

This standardized Agena, as you probably know, is designed to play a series of important roles in both military and civilian space programs.

By the very standardization of the vehicle, permitting a variety of instrumentation, equipment, and payloads, this Agena is destined to save millions of dollars in the space program. It is scheduled for participation in a variety of programs for the Department of Defense and more than a dozen programs for NASA.

In just 10 months from receipt of the go-ahead contract on August 25, 1961, this vehicle was developed, built, and test fired with completely satisfactory performance. All phases of it were conducted on schedule and within cost on an incentive contract.

We should like to tell you briefly about the Government-industrial management system for this program that made this achievement possible:

1. The Air Force and Lockheed worked out an unusually careful definition of the vehicle, its performance requirements, the desired schedule, and the related work required. There was a precise understanding from the outset of the exact work to be accomplished by each of the participants. This was one of our most vital management accomplishments. If applied effectively across the board, it could result in significant savings in the overall space effort.

2. The Air Force and Lockheed jointly developed working arrangements far more specifically than has been the practice. We established clear channels of communication. We agreed upon a drastic reduction in reports and documentation. We agreed upon the specific extent of testing to be carried out during the development. This mutual delineation, prior to the start of the program, precluded later confusion or lost time in the essential discussions and relationships during conduct of the program.

3. It then became feasible to establish a project organization within the Lockheed Missiles & Space Co. with clean lines of authority at the various levels of management. This permitted the work of individual groups to be integrated and coordinated without duplication of effort or confusion over precise responsibilities. It permitted quicker decisionmaking at lower levels of the organization. When problems arose, as is inevitable in any development program, individual engineers or managers knew exactly where to get an authoritative decision at the earliest moment. While hard to measure the results in dollars or days, we know that this type of organization and delegation of decisionmaking authority saves time and money.

4. The time schedule was compressed at the start to the minimum considered possible by the Government and the contractor. Any well-managed program will cost less if scheduled for the minimum reasonable time consistent with the technology involved. Tightly scheduled programs provide an incentive to all people working on the program. They preclude any tendency for the application of excess manpower. These facets reduce the cost of program accomplishment in general. And they helped in our successfully completing the first flight 1 day ahead of the schedule established in August 1961.

5. Utilization of an incentive form of contract when the state-of-the-art permits assures that both the Government and the contractor will strive to keep costs to a minimum. In the case of the standardized Agena the program costs are currently in line with the contracted amount.

The second area that we want to mention because it offers a substantial possibility for reducing overall costs of the Nation's space program is that of technological improvements. In this letter we would like to confine our comments to the field of propulsion.

The high cost of putting a pound of payload into orbit or deep space mission is due in major degree to the large amount of energy required. Therefore any development leading to a more efficient of powerful propulsion system can be a key factor in reducing the cost of space operations.

One line of endeavor that promises a substantial return for each dollar expended is in nuclear propulsion for space vehicles. Our studies have indicated that substitution of a nuclear stage for a chemical stage on vehicles already under development promises a significant improvement in performance. On an advanced lunar or planetary fly-by mission, the cost per pound of payload may be reduced to approximately one-half the cost of an all-chemical system by using a nuclear upper stage. For more ambitious missions, such as probes to the more distant planets or for solar satellites, performance three to seven times that of an all-chemical vehicle might be achieved by substitution of a nuclear stage on such vehicles as Saturn C–5. Improvements of this degree obviously permit lower propulsion cost for a fixed payload or greatly increased payloads for fixed propulsion costs.

Another technological promise of reducing costs is in the development of large solid propellant boosters. Though liquid propellant boosters today have higher energy per pound of propellent, the solid booster system offers significant reductions in both technical and operational complexity. Further development effort could well lead to an improvement in the energy potential of both solid and liquid fuels.

We realize that these comments are somewhat broad and that more specific information can be more helpful to you in your efforts to learn how space program costs might be minimized or more effective results attained from the planned expenditures. Should you wish to follow up on the suggestions we have made, we shall be very happy to supply additional information or answer specific questions you may have.

Sincerely,

COURTLANDT S. GROSS, *Chairman.*

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