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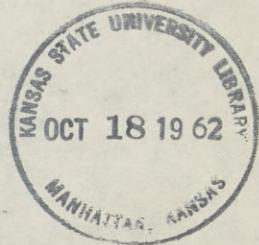
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HEARINGS  
BEFORE THE  
SPECIAL SUBCOMMITTEE ON PROPULSION  
OF THE  
COMMITTEE ON  
SCIENCE AND ASTRONAUTICS  
U.S. HOUSE OF REPRESENTATIVES  
EIGHTY-SEVENTH CONGRESS  
SECOND SESSION

AUGUST 8 AND 9, 1962

[No. 10]

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NOTE.—The chairman and the ranking minority member (Mr. Martin, Massachusetts) are ex-officio members of all subcommittees.



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## DEVELOPMENT OF LARGE SOLID PROPELLANT BOOSTERS

WEDNESDAY, AUGUST 8, 1962

HOUSE OF REPRESENTATIVES,  
SPECIAL SUBCOMMITTEE ON SOLID PROPELLANTS,  
COMMITTEE ON SCIENCE AND ASTRONAUTICS,  
*Washington, D.C.*

The committee met at 10 a.m., the Honorable David S. King (chairman) presiding.

Mr. KING. The subcommittee will come to order noting that we are represented on both sides of the aisle.

There will be others that will join us in a few minutes.

The purpose of these hearings is to review the large solid propellant booster program and to determine what can and should be done to make sure every effort is being made to effectively and efficiently develop the capability of providing large solid boosters in a timely manner to carry out the U.S. space exploration program, and insure the achievement of our national space objectives.

As you will recall, NASA and the Department of Defense presented a joint solid motor development program amounting to \$158.3 million, which was to be supervised and managed by the U.S. Air Force. Recent articles in the press indicate that this program, as presented during the NASA authorization hearings, has been materially changed due to recent decisions by the Department of Defense and that the development of the 156-inch and the 240-inch solid propellant motors has been dropped. Therefore, the committee, at this time, feels it is necessary to review the large solid research and development program to determine what changes have been made and their application to future program objectives.

It will also be of major committee interest to discuss and evaluate schedules, future milestones, and determine how the future research and development program will be supervised, managed, and funded to meet NASA's requirements.

Hearings will be held for 2 days on the 8th and 9th of August; with NASA testifying on the 8th of August and the Department of Defense Air Force on the 9th of August.

Today, Mr. Thomas Dixon, Deputy Associate Administrator of NASA, is here with Mr. William Cohen, Chief, Solid Propulsion Systems, Office of Manned Space Flight, to represent NASA. If you are ready, Mr. Dixon, you may proceed.

Mr. DIXON. Yes, sir.

Mr. KING. I understand further, Mr. Dixon, that you do have a prepared statement that you would like to give.

Mr. DIXON. Yes, sir.

Mr. KING. Following that I have some questions that have been prepared by the committee.

It may be that the questions will have been in part answered by your discussion, but in any event we will proceed with your prepared statement first, followed by our questions.

Mr. DIXON. Mr. Chairman, I would like to read my prepared statement, which is a summary of the overall program, and then Mr. Cohen would like to give his prepared statement which is in more detail of the problems and program aspects of the large solid rocket.

**STATEMENT OF THOMAS F. DIXON, DEPUTY ASSOCIATE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

I wish to state NASA's position on solid propulsion elements for large space vehicles. We are giving solid rockets equal consideration with liquid rockets in making our decisions on future launch vehicle designs.

In continuing to do this, we believe that it is necessary to demonstrate the engineering feasibility of solid rocket motors by full-scale static firing tests.

Therefore, we have provided the Department of Defense and specifically the Air Force with our requirements for an advanced technology or feasibility demonstration program on large solid rocket motors pertinent to the development of solid rocket powered launch vehicles.

I want to make clear to you that an advanced technology program on large solid rocket motors does not constitute a launch vehicle development program.

We are asking for a feasibility demonstration of motors of the size and thrust level that seem most appropriate to our long-range vehicle plans.

We do not wish to give the impression that our recommendation for this demonstration program means that we will definitely adopt these motors in our vehicles. We feel, however, that to make an informed choice of propulsion between liquid propellant engines where the technology is fairly well in hand, and solid propellant motors where it is not, it is necessary to advance the technology of large solid motors to the point of actual demonstration firings.

The demonstration program we have proposed will allow us to make a wise choice between the two types of propulsion because a better understanding of costs and schedules as well as developmental problems will be available.

As you know, by the agreement between Department of Defense and NASA, the Air Force will fund and provide for technical direction of the advanced technology program on the large solid propellant motors.

We recognize that we are asking the DOD to expend appreciable funds on tasks for which there is no immediate military application.

It is wise to pursue this program, however, since the selection of the proper propulsion elements for future large space vehicles is so fundamental and important to the national space program.

I will now review, in broad terms, the NASA activity in the large solid propulsion field, and our coordination with the DOD in this program.

This activity falls into three categories. The first is the establishment of NASA inhouse activities and NASA contracts to obtain the necessary information relating to the use of these motors in NASA missions.

The second is the definition and establishment of the overall program for testing and evaluating materials and concepts that may be applicable to systems using solid propellant motors.

The third is the supporting development and advanced technology program for testing and evaluating materials and concepts that may be applicable to systems using solid propellant motors.

The first area of endeavor I mentioned is NASA inhouse and contractor effort to obtain information on the problems associated with the use of solid propellant elements.

These programs deal mostly with the question of the use of a solid stage together with a liquid stage, the vehicle dynamics that result from such a configuration, the guidance and control problem, the vehicle integration and check-out problems, and so forth.

We have directed Marshall Space Flight Center to establish an organized program to work on these problems. Our other field stations have been informed of our policy and our intent with respect to solid propellants. Work has started inhouse at Marshall.

NASA has also established a number of industrial contracts to deal with this category of problems. The Boeing Co. is working on studies of complete launch vehicle systems containing solid stages; Aerojet-General Corp. is studying the special problems associated with clustering the large solid propellant motors I described; Lockheed Co. is working on a stage analysis which will give us much information about the problem of a vehicle with both a solid propellant stage and liquid propellant stage.

Recently we selected General Dynamics/Astronautics and the Martin Co. to study possible NOVA systems. Their study tasks have been clearly spelled out to include solid propellant elements.

We have contracts with two companies (Aerojet-General and Thiokol) to work on the failure warning systems that must be developed if the solid propellant stages are to be used in manned vehicles.

Another contractor (Stanford Research Institute) is delving into the explosion or detonation hazards that are associated with the use of the large solid motors I described. We have had a contract to deal with the high-noise level associated with the multimillion-pound thrust stages made of solid propellant motors (Conesco).

In summary, we are carrying out the parts of the program which are NASA's responsibilities in areas other than the development and testing of the individual rocket motor.

In the second area of endeavor, I can report that NASA has studied our potential applications for solid propulsion motors. We have transmitted our desires for a program of motor demonstration to the Department of Defense and are working closely with DOD and Air Force to establish the details of this program.

We have concluded that two motors, one of 3 million pounds thrust and one of 6 million pounds thrust, are of interest. The two motors represent two different methods of manufacture and involve different methods of transportation, handling, and possibly of vehicle assembly. The smaller motor, which will deliver 3 million pounds

of thrust for more than 120 seconds, will be a large segmented design.

You are familiar with the concept of segmenting. Basically, it involves the manufacture of a motor in pieces which can be made in existing facilities, can be transported by rail if desired, can be handled by standard cranes and rolling stock, and finally can be assembled fairly easily into a full rocket motor and stage.

We are impressed by the flexibility and ease of use of this size motor, and accordingly have requested a minimum demonstration program at the 3 million-pound-thrust level.

Several smaller motors which are assembled from segments have already been tested. Although these tests have been quite successful, before we go forward on a launch vehicle development program we believe it desirable to proceed with the construction and demonstration of a motor in the 3 million-pound class.

The segmented motor we are recommending to obtain the critical technology is the largest motor whose segments can be transported by rail and which can be made fairly easily in existing facilities.

The dimensions will be 156 inches in diameter by approximately 150 feet in length. This is a major scale up in both physical dimensions and thrust level.

The second motor which would produce 6 million pounds thrust, requires a completely different technology of manufacture, transport, handling, and assembly which, when developed, gives the potential for very high thrust levels.

We are interested in the demonstration of six million pounds of thrust over a burning time of about 2 minutes. This motor will be approximately 22 feet in diameter by about 130 feet long. It is so large and heavy that it will have to be made and handled by new methods.

We expect that the propellant charge, which will weigh about 3 million pounds, will be cast in one or possibly two large pieces.

The motor, after manufacture, will have to be transported to the receiving site by water, and probably will have to be handled by water thereafter, when it is made into a stage and mated with the rest of the launch vehicle.

I am sure you perceive that the major expense and difficulty in the two demonstration programs we feel to be necessary is related to this motor. We have accepted these problems because the high-thrust level and the growth potential of the motor seem very attractive to us.

As stated previously, we have transmitted our requirements for this program of motor demonstrations to the Department of Defense and are working closely with DOD and the Air Force to establish the details of programs to carry it out.

We have had fine cooperation from the DOD to date, to define a program which will be mutually acceptable to the DOD and NASA, and to the best interests of the space program.

We are presently working with the DOD in an effort to establish in detail a mutually acceptable program for review by higher authority.

The third area of endeavor is that of supporting development and advanced research and technology. Here, NASA directs an inhouse and industrial program for investigating new components, new materials, and new concepts.

Examples of this kind of activity are an investigation into the stress and strain patterns inside very thick propellant charges; investigation of methods of producing steering forces in very large rockets; the investigation of new steel compositions which may be applicable to very large motor cases.

Many other programs are supported, too numerous to describe in detail now. Mr. Cohen will discuss these in a moment.

The key point I wish to make, however, is that NASA recognizes its responsibility to fund and support this kind of work, and to coordinate it closely with the similar activities of the Department of Defense.

Let me repeat, in conclusion, what I said when I began today. NASA is giving full and complete consideration to solid propulsion elements for its space vehicles.

Before we can commit a vehicle to this type of propulsion, we believe it desirable to have demonstrated the full-scale motors of interest to us. We are in the final stages of defining a program to do this with the Air Force and DOD.

Within NASA we are doing the many tasks needed on the technology and logistics of launch systems using solid propellant motors.

NASA is also examining the use of new materials, components, and techniques in a supporting technology and research program.

Mr. Cohen will now give the technical details of the program I have described.

Mr. KING. Thank you very much, Mr. Dixon, for a very splendid statement; we are grateful to you for reading it, and for the copies made available to us.

Perhaps at this time, if it is agreeable with the members of the committee, we could proceed with Mr. Cohen's statement, and save our questions until afterward.

#### STATEMENT OF WILLIAM COHEN, CHIEF, SOLID PROPULSION, OFFICE OF MANNED SPACE FLIGHT, NASA

Mr. COHEN. Good morning, gentlemen.

I am going to describe the status of the technology of large solid propellant rocket motors and stages. I will show that much progress has been made in the past year and a half in large solid rocket technology, and I will describe a program which takes full advantage of this technology and leads to the demonstration of very large, high-thrust motors potentially usable in space launch vehicles.

The large motors for these vehicles will represent a growth of 10 times in thrust level, 10 times in weight, and more than 2 times in diameter over the largest solid rocket motors tested up to now, and a much greater growth over the largest motor now in full production.

These motor programs, the vehicle systems tasks, and the supporting technology programs are designed to place NASA in a rational position for selecting propulsion systems.

The first illustration (fig. 1: Comparison of large solid motors) shows the size, weight, and thrust level of the two large motors mentioned by Mr. Dixon, and also shows a comparison with a motor 120 inches in diameter, under consideration for development by the Department of Defense.

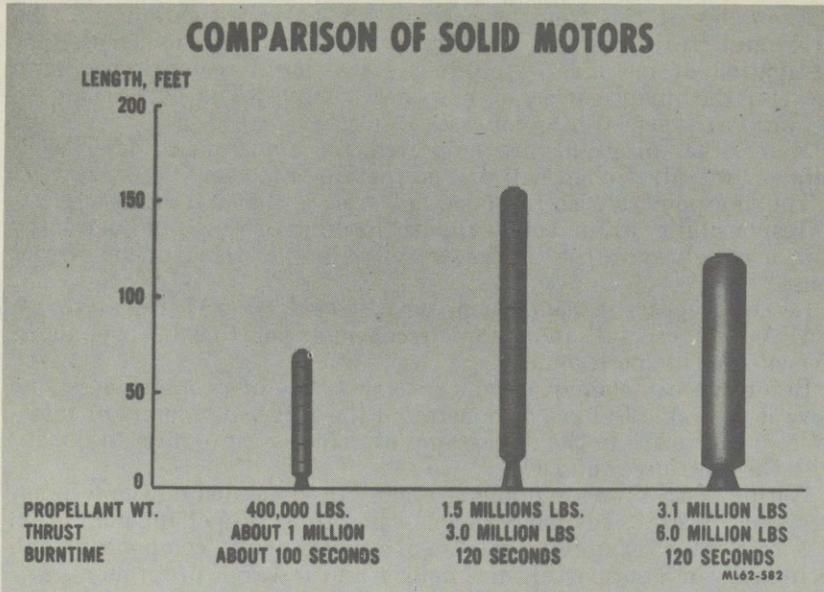


FIGURE 1

NASA's philosophy, as just stated by Mr. Dixon, is to require demonstration firings of the large motors, in order that a rational choice of propulsion may be made.

The 156-inch diameter motor illustrated in the center represents about the limit of motor segmenting technology. The 260-inch diameter motor shown on the right represents a new class of technology which accepts the fact that the weight and dimensions of the motor are so great that new manufacturing and transportation methods must be applied. I will go into more details concerning this difference later in my talk.

You will note that many more of the smaller 120-inch motors would have to be used in those stages calling for the 156- or 260-inch diameter motor.

Roughly four times the number of 156-inch motors and eight times the number of 260-inch motors would be required per stage if we attempted to use the smaller 120-inch motor.

You observe that we are calling for ambitious advances in technology, with the accompanying requirement for large outlays of funds.

The next few slides will show that sufficient progress has been made in testing of smaller motors or segments of motors to justify this step forward.

This slide (fig. 2: National large solid motor program) shows that a large amount of effort has been expended and much progress made in the area of large solid rocket motors during the past 2 years.

The motors illustrated here were part of an orderly program which is intended to demonstrate the key technology of large solid rocket motors.

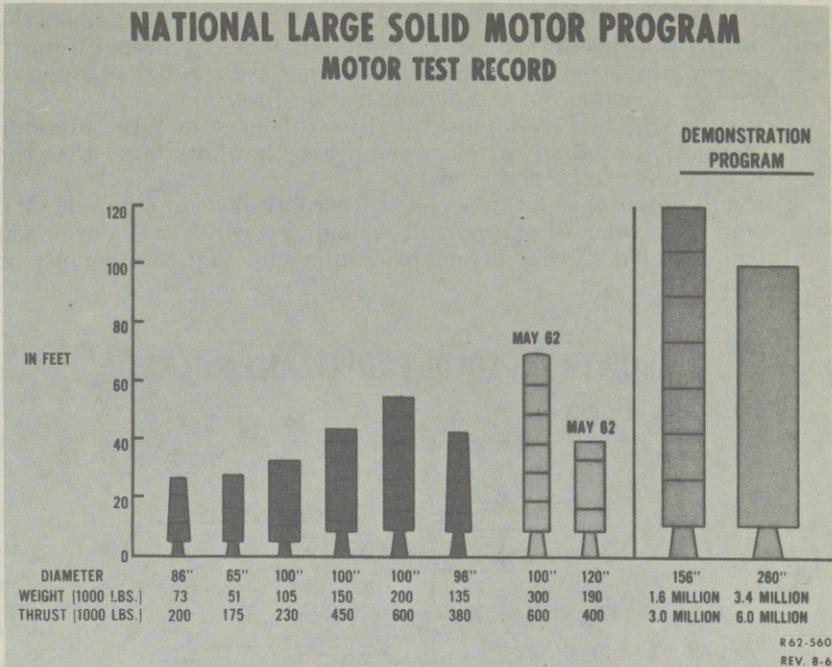


FIGURE 2

We consider this technology to be the following:

(1) the establishment of insulation systems for the interior of the motor;

(2) the establishment of mechanical joint designs and of insulation for joint regions;

(3) the establishment of nozzle structures and materials for long burning time;

(4) the demonstration of methods for processing very large propellant charges;

(5) the development and demonstration of thrust vector control systems for long-burn-time motors; and

(6) the development of handling and transport methods for motors of very large size and weight.

The progress to date has been gratifying and encouraging. As you can observe from the chart, thrust levels up to 700,000 pounds and durations greater than 120 seconds have been demonstrated.

A number of mechanical joint designs have been proved out, and a great deal of information has been obtained about the design of the insulation systems for the joint region and for the motor itself.

Much encouraging data have been obtained with respect to the secondary fluid injection method of obtaining vector control.

The two motors under the heading "Demonstration program" are those which we believe have potential application in the national space program.

At the present time we, and the Air Force people responsible for the solid propulsion programs, are in the final stages of preparation of a document which will be the basic Request for Proposal package to industry for carrying out the demonstration program.

This slide (fig. 3: Development and test of large motors) presents the information of the previous one on a scale of years so that the rate of progress can be observed.

You will notice that progress has been continuous and rapid. We also show here some of the critical technology which was developed and demonstrated in the various programs, and that which must be worked on.

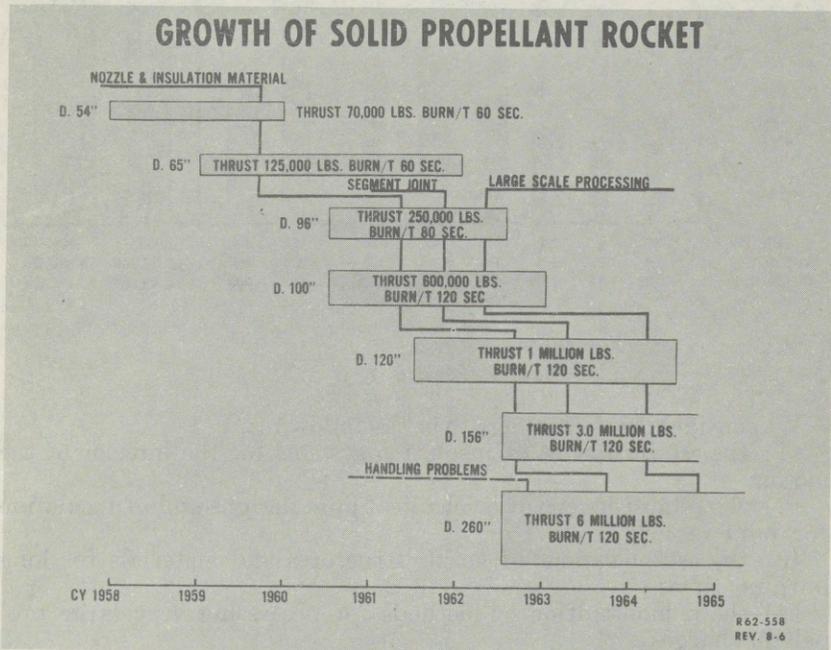


FIGURE 3

Notice that the demonstration of nozzle materials and internal insulation has flowed in a regular progression from the early work on the 54-inch motors typical of Polaris motors, through the other sizes, into the very large program.

Some technology items are unique to the larger sizes of motors; these are items such as the joint design and insulation and the problems associated with manufacture and handling of very large and heavy rockets.

The next slides show three of the large motors that have been fired. Here (fig. 4: Large motor tested by United Technology Corp.), you see the test of a motor containing about 130,000 pounds of propellant, which produced a thrust of 380,000 pounds over a burning time of approximately 80 seconds.

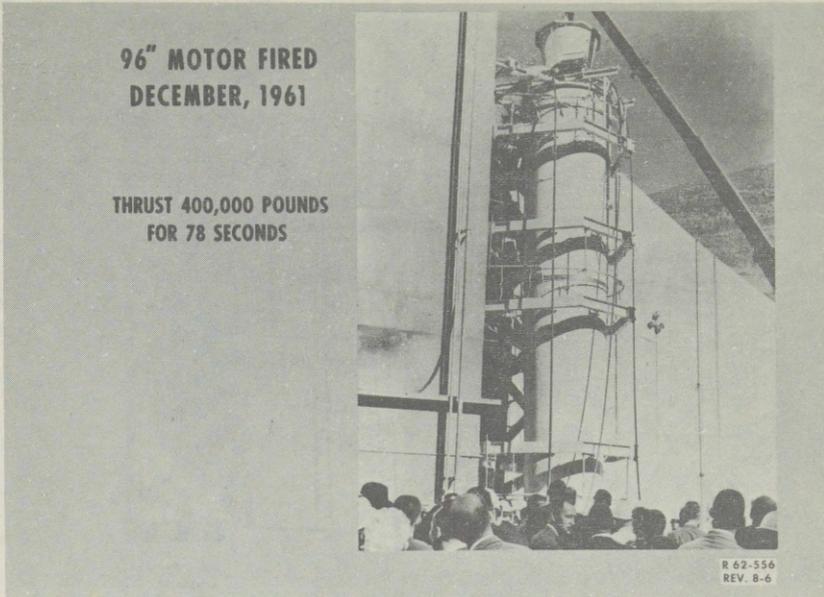


FIGURE 4

The contractor in this firing was United Technology Corp. of Sunnyvale, Calif. The motor was made in four single pieces and assembled vertically on the firing stand.

This slide (fig. 5: Assembly of 96-inch motor) shows the scale of motor size in relation to the two men who are making adjustments to the piping for the liquid injection system in the nozzle.

This slide (fig. 6: Large motor tested by Aerojet-General) shows another motor tested in the large motor program, also of the segmented design. Notice that it is fired horizontally. The motor produced a peak thrust of 600,000 pounds for a burning time greater than 90 seconds. It contained about 220,000 pounds of propellant.

This slide (fig. 7: Motor fired in May 1962 by Lockheed Propulsion Co.) shows the case of a motor which was fired in the month of May.

It is 120 inches in diameter, the largest diameter of any motor yet tested. The burning time was over 120 seconds, which is about the time required for the motors for space launch vehicles. The trust level was about 400,000 pounds and the weight of the loaded motor was approximately 190,000 pounds. The contractor is the Lockheed Propulsion Co.

In the next part of my discussion, I will go into details of the technology involved in the programs in which we are interested.

The next illustration (fig. 8: Concept of segmented motor) and the few following will give details of the concept of the segmented rocket motor, the possible modes of transportation, and some possible assembly methods.

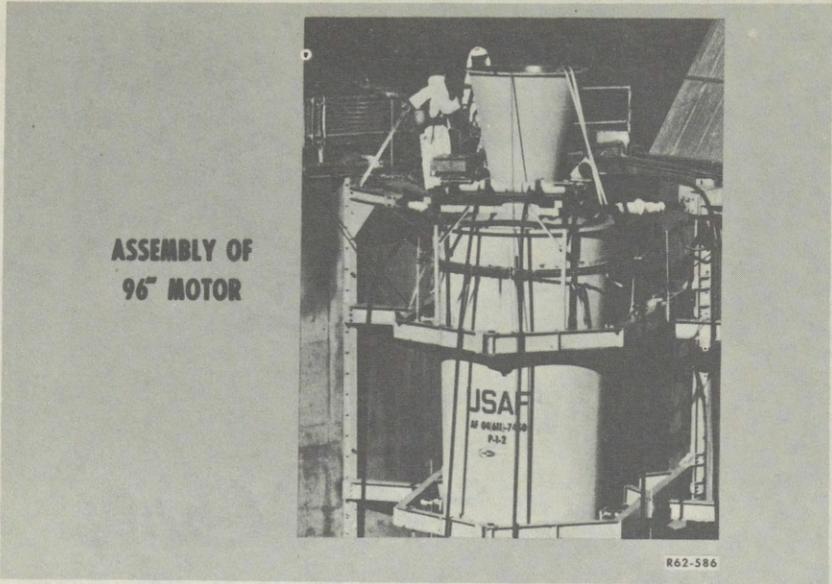


FIGURE 5

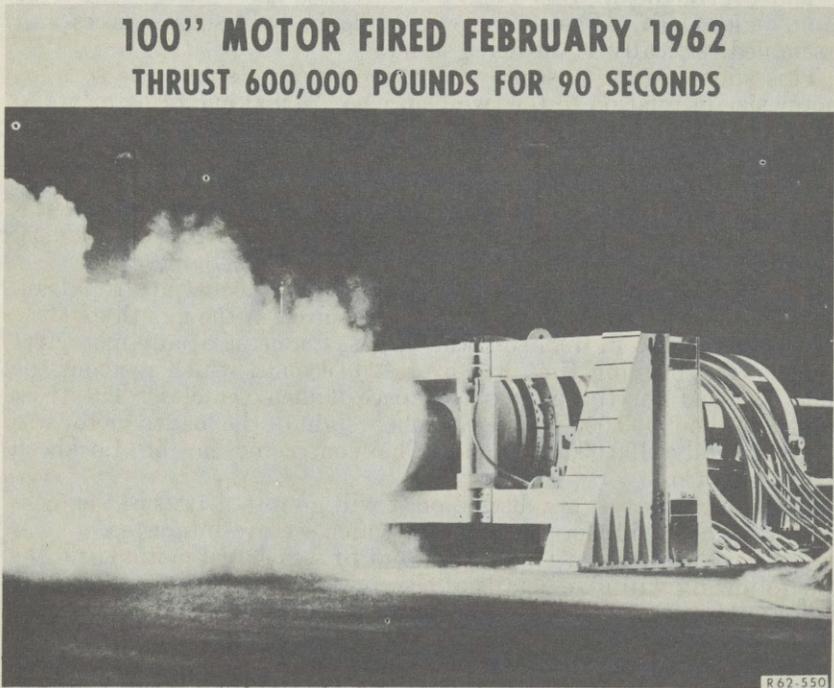


FIGURE 6

**120" MOTOR FIRED MAY 1962  
THRUST 400,000 POUNDS FOR 120 SECONDS**

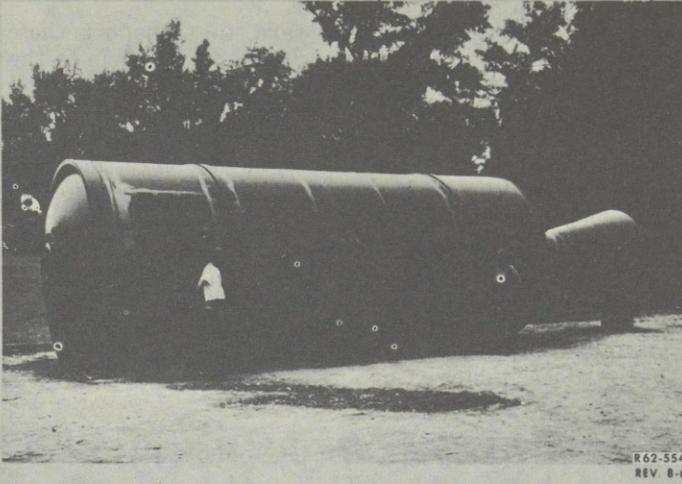


FIGURE 7

**CONCEPT OF THE SEGMENTED MOTOR**

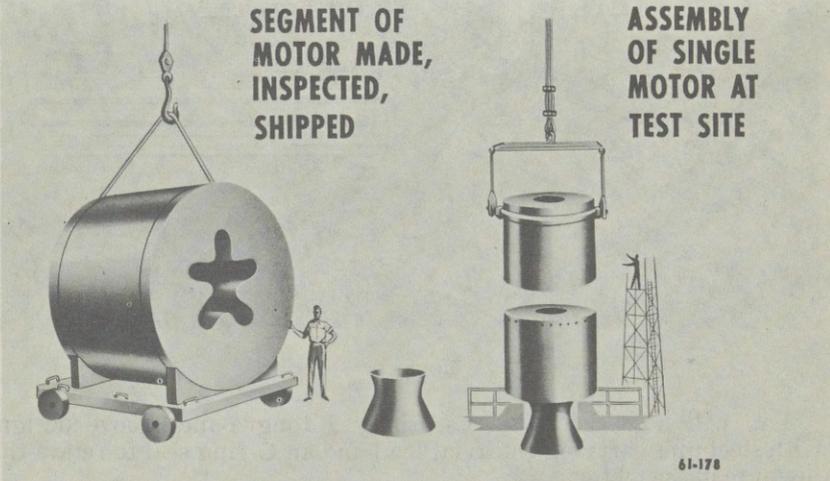


FIGURE 8

You will notice that each motor is made in a number of individual parts; in the full motor there might be six or seven of these.

By making the motor in small parts, it becomes possible to use the technology that has been developed for making motors like MINUTE-MAN and POLARIS.

It becomes relatively straightforward to transport these pieces around the manufacturing plant and later to ship them to the launch site. In addition, the fact that the motor segment is relatively small means that it is easy to inspect the ends and the interior.

All of the effort that I described earlier in the large motor program has been devoted to motors made in segments, since the proof of the strength and reliability of the segment joint was absolutely essential in the large motor program.

The results with respect to the segment have been very good. There has never been a failure of any kind of a joint or its insulation, and indeed there has been no indication of any incipient failures.

This slide (fig. 9: Example of joint design) shows the design of one of the joints developed for segmented motors and used in the motors tested at United Technology Corp.

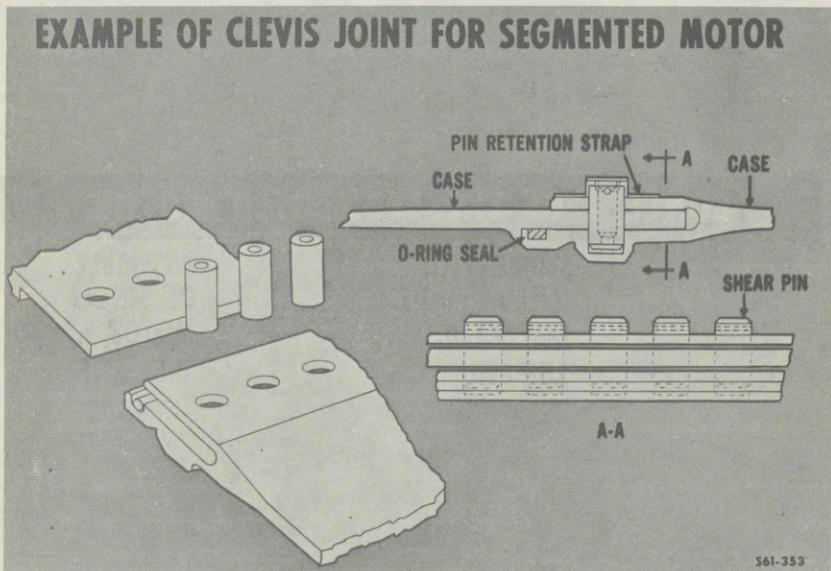


FIGURE 9

You will note that it is essentially a tongue-and-groove design, with steel pins carrying the avial load and an O-ring seal to retain the pressure in the motor.

Two other joint designs have been evaluated in the motor tests I illustrated earlier, and all have worked well.

We see here (fig. 10: Transport of segment by truck) one of the methods by which a segment of a motor might be transported. This slide shows a mockup of a segment 156 inches in diameter being moved around a manufacturing plant on a truck.

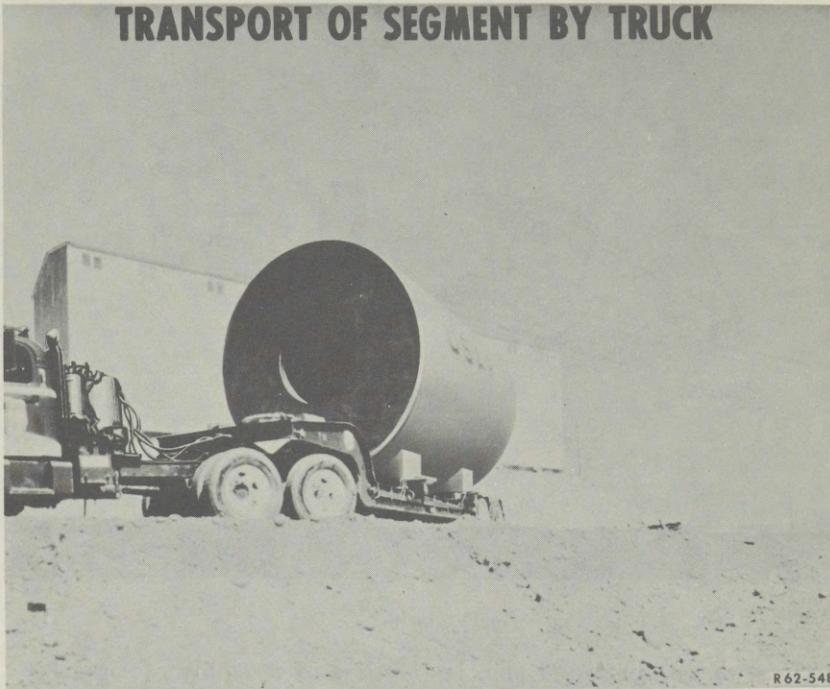


FIGURE 10

This is an exercise to determine what the problems of loading trucks would be and the problems of clearances in a specific plant.

Truck transportation might be used for loaded segmented motors for transport between a manufacturing plant to a railhead, and rail transportation used to take the segments to the launch site.

This slide (fig. 11: Transport of segment by rail) illustrates the possible method of transportation of the segment by railroad flatcar. The basic controlling factor on the diameter of the large segmented motor is the size capacity of railroad lines.

Railroads can transport loads with maximum diameter of approximately 160 inches and with weights of 300,000 or 400,000 pounds. Our motor will be made of segments 156 inches in diameter, which allows for a packing container, and each segment will weigh about 250,000 pounds.

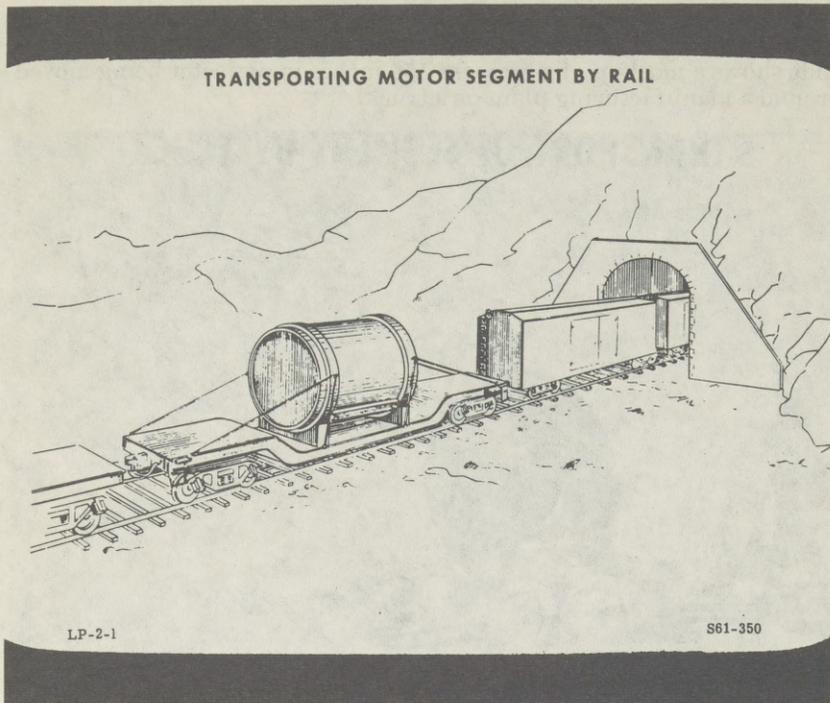


FIGURE 11

Here we see illustrated (fig. 12: Method of assembly of segmented motor and stage) one method that might be used to construct a booster stage of segmented motors. The segment is the basic building block of the system and the motors and stage are built up by placing one segment upon another.

Here is the motor which we are recommending for test (fig. 13: Specifications of 156-inch diameter motor). It is, as I said before, essentially the largest motor of the segmented design which can be transported around the country by rail.

The amount of propellant, about  $1\frac{1}{2}$  million pounds, cannot be increased appreciably because the internal flow conditions of the combustion gases have reached about the limiting velocity desirable in a motor.

This slide (fig. 14: Concept of the monolithic motor) illustrates a number of the special features and problems that are associated with motors made in one piece, which are larger than about 14 feet in diameter.

These very large motors have very high thrust; we believe they should be investigated because they are potentially applicable to a number of high payload missions, and because they have growth potential for postlunar missions.

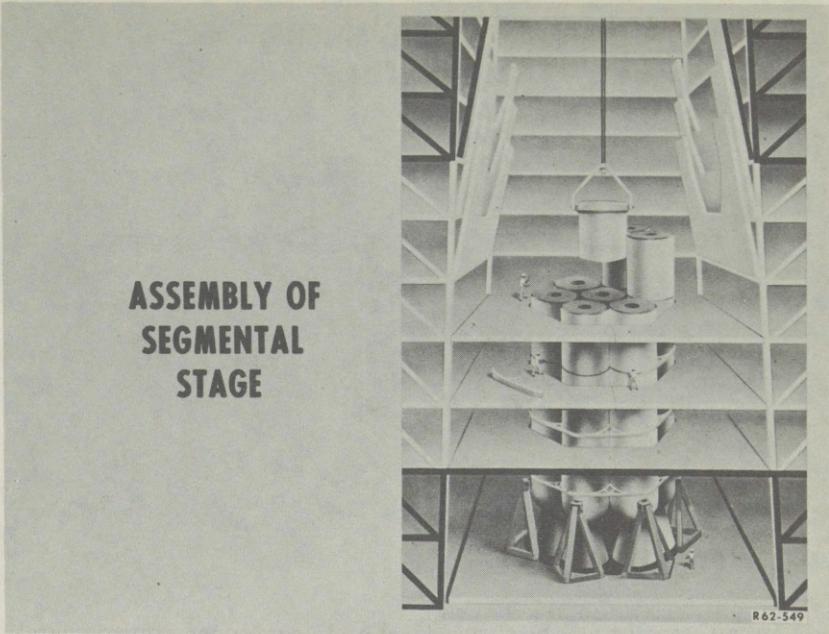


FIGURE 12

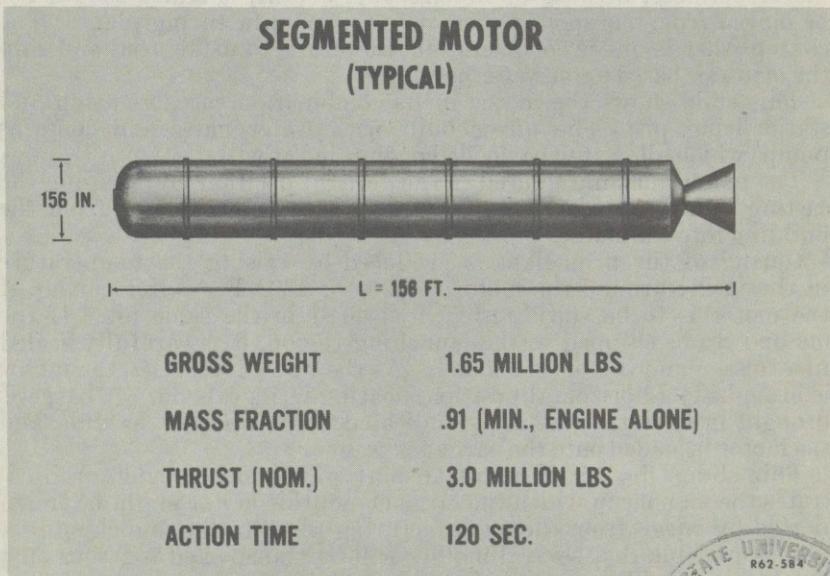


FIGURE 13



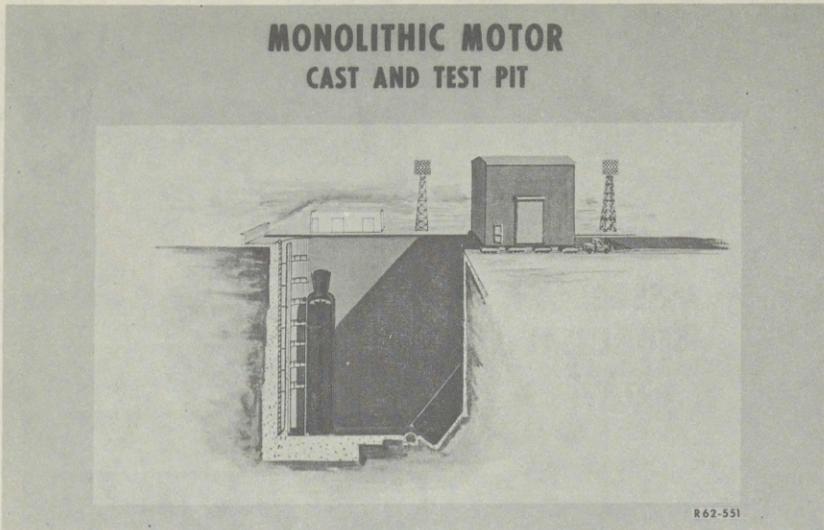


FIGURE 14

You will recall that the thrust level of this motor is approximately 6 million pounds for a burning time of 120 seconds. The motor is so large in diameter and so heavy, weighing over 3 million pounds, that it cannot be moved by any practical means except water transportation.

Furthermore, because of its size and weight, it really should not be moved from one spot to another in the manufacturing plant. The concept that is under consideration, therefore, to make, test, and ship the motor, is based upon water handling.

This slide shows the motor in its combination casting-curing and static firing pit. The pit is built with water gates and contains pumps which allow it to be flooded or emptied at will.

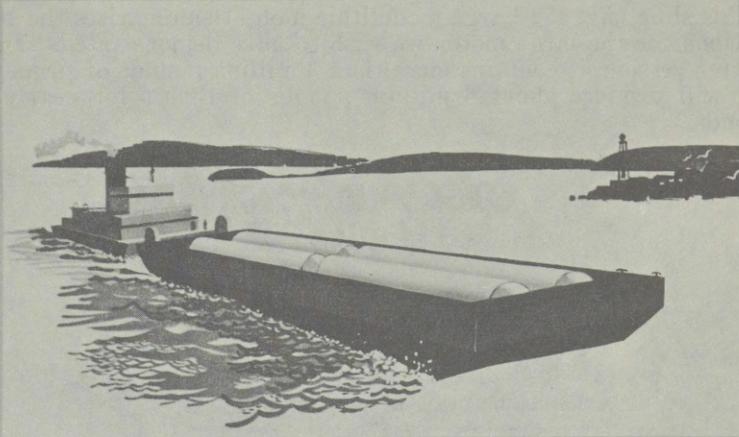
The motor is manufactured in the vertical position, by bringing the casting building over the top and pouring the propellant from the building into the motor.

Curing of the propellant is produced by raising the temperature in the jacket around the motor to 120° or 130° F. After curing, if the motor is to be static tested, it is fired in the same pit. If the motor is to be shipped to the launching region, it is carefully sealed in a caisson and the pit is flooded. As the water level rises, the motor is brought to a horizontal position, floating in its caisson. A barge is brought in from the waterway, indicated to the right of the slide, and the motor is loaded onto the barge for transit.

This slide (fig. 15: Water transport of monolithic motor) illustrates the manner in which the large monolithic motor might be transported by barge from the manufacturing plant to the launch site.

It is possible that several motors will be transported together on a single barge. The motors are protected from the elements during transportation by the watertight caisson in which they are sealed.

### MONOLITHIC MOTOR TRANSPORTATION TO LAUNCH BASE

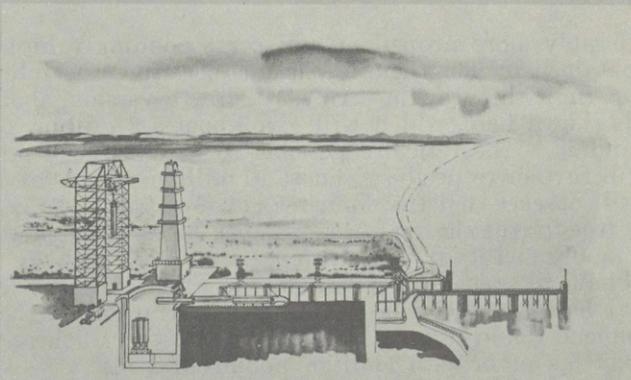


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FIGURE 15

At the launch site, the barge containing the motor is brought in through another canal and is unloaded in the reverse manner described for loading (fig. 16: Receiving of monolithic motor at launch site).

### MONOLITHIC MOTOR RECEIVING AT LAUNCH BASE



R 62-552

FIGURE 16

In considering the concept of the water-handling technique for the large monolithic motor, we must keep in mind the very large water transportation industry that exists in the country at present. Water handling of very heavy and large cargo is a well-established technique and can easily accommodate large rocket motors.

This slide (fig. 17: Large monolithic motor) summarizes the specifications for the large motor we wish to have demonstrated. In the shorter version, it contains more than 3 million pounds of propellant and will produce about 6 million pounds of thrust for nearly 120 seconds.

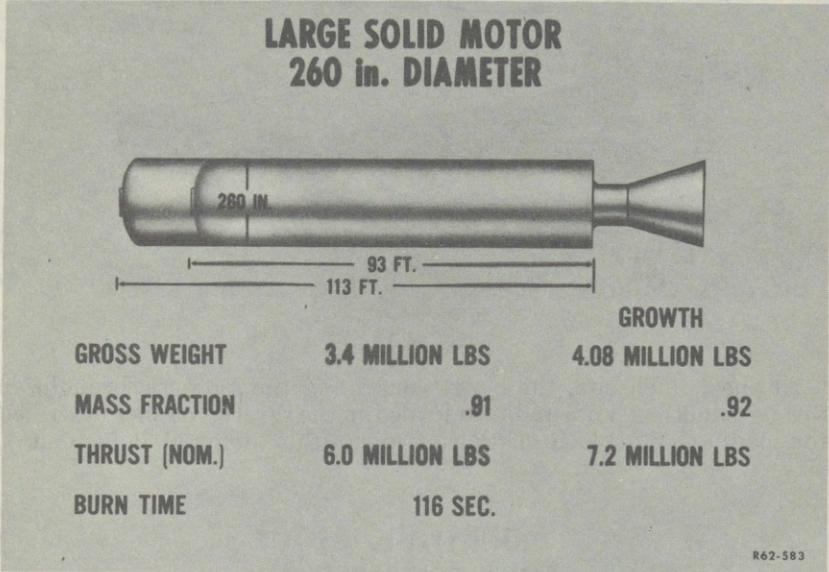


FIGURE 17

Considerably more propellant and correspondingly higher thrust can be obtained by lengthening the motor before the internal flow conditions limit the growth. An easy growth version, about 20 feet longer, is shown here, which will give about 7.2 million pounds of thrust, and it is theoretically possible to extend the length of the motor still further to produce almost 10 million pounds of thrust.

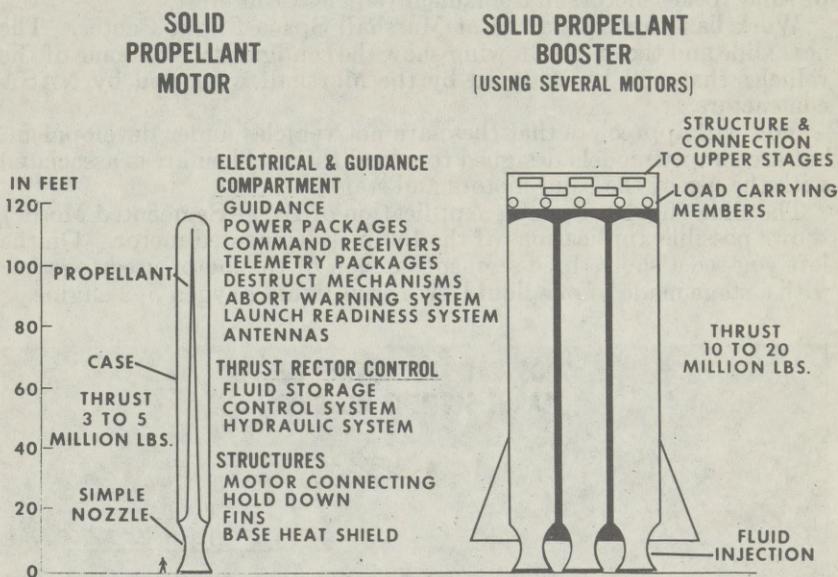
You will observe that the diameter is 260 inches and the length is about 93 feet for the shorter version shown here. This motor cannot be made in any facility now in existence.

It will have to be made, tested, and if necessary transported by the methods I have just described. The demonstration program which we recommend would culminate in the static testing of three full-scale versions of this motor with 6 million pounds of thrust.

The next part of my discussion will cover the effort of NASA to obtain information on the problems associated with the use of solid-propellant motors in space launch vehicles.

The next slide (fig. 18: Difference Between Motor and Stage) has the purpose of refreshing your memory about the difference between a motor and a booster stage. The stage consists of a number of individual motors bound together with a supporting structure, an interstage structure which is secured to the upper liquid-propellant stages and which must transmit the high thrust to that stage, and numerous items of telemetry, power, operating devices, electronics, etc., necessary for the operation of the total vehicle.

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FIGURE 18

The stage might also contain the components of what is known as the fluid-injection system for obtaining steering forces on the vehicle.

This would consist of storage tanks for liquids, valving, pressure bottles for forcing the liquid into the nozzles, batteries for operating valves, electronic components for sensing the valve position, etc. A great deal of effort, time, and money is required to produce a complete stage from the individual rocket motors.

Before a stage design and development program can begin, it is necessary to obtain much information about the interaction of the solid-propellant stage with the other elements of the launch vehicle.

In addition, it is necessary to find out a great deal about the method of mating the solid-propellant stage to the vehicle, and of the method for preparing the vehicle for launching.

It is necessary to determine what is known as the vehicle dynamics and how this relates to the guidance system. The vehicle dynamics

describe how the total vehicle bends and deforms under the influence of the thrust of a stage and under the loads produced by crosswinds and by the aerodynamic forces of the atmosphere.

If the vehicle dynamics are not properly established and controlled, it is possible for the guidance system to be deceived by the vibration of the vehicle and for it to give a spurious command to the attitude control system.

This is the first area of endeavor mentioned by Mr. Dixon. NASA is proceeding to carry out a family of tasks, both in-house and with contractors, to spell out clearly the problems associated with the use of solid rocket motors in the launch vehicles of interest.

Work has already started at Marshall Space Flight Center. The next slide and the ones following show the configuration of some of the vehicles that will be analyzed by the Marshall work and by NASA contractors.

You will appreciate that these are not vehicles under development, but are simply models designed to reveal the problem areas associated with the use of the solid motors and stages.

The slide (fig. 19: Possible Application of Large Segmented Motor) shows possible applications of the 156-inch segmented motor. On the left you see a short three-segment version of the motor used together with a stage made of one liquid hydrogen-liquid oxygen J-2 engine.

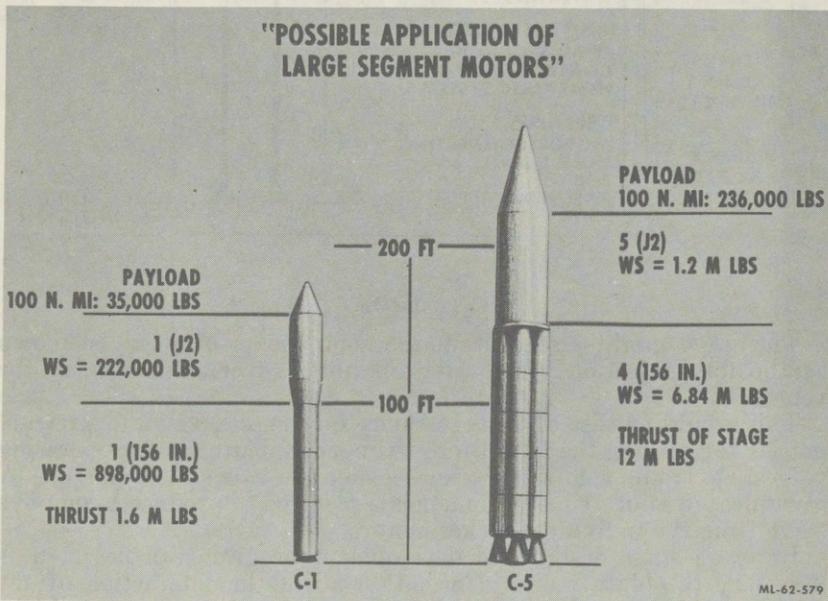


FIGURE 19

It is capable of placing a payload of 35,000 pounds into a 100-nautical-mile orbit. The vehicle on the right is in the so-called C-5 class.

It can place 236,000 pounds into orbit. Here, four of the full 156-inch motors form a first stage with five of the J-2 engines as the second stage.

The next slide (fig. 20: Possible Application of Large Solid Motors) shows larger vehicles of the NOVA class. The solid-propellant stages for these vehicles weigh over 12 million pounds. They might be formed of four of the 260-inch motors or eight of the 156-inch motors.

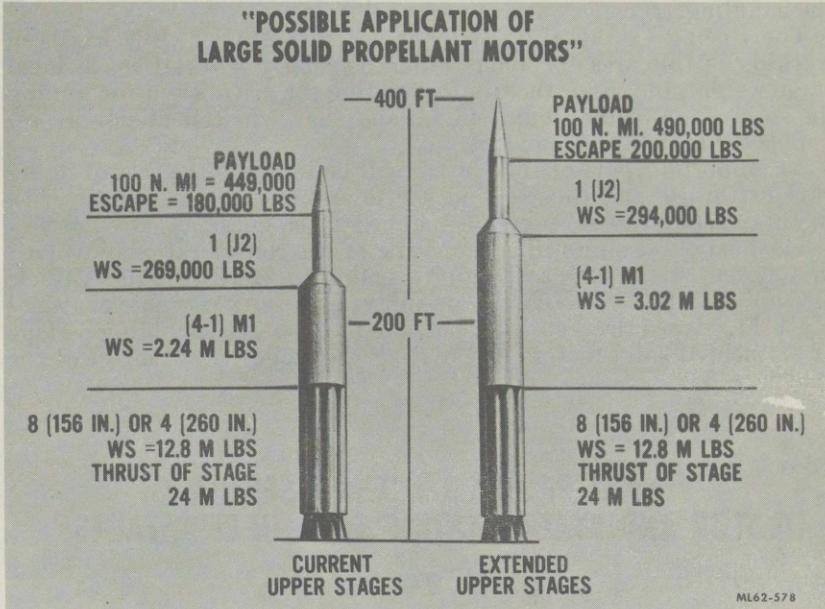


FIGURE 20

The stage thrust is about 24 million pounds. The upper stage of these vehicles would make use of the new liquid hydrogen-liquid oxygen M-1 engine, which produces 1.2 million pounds of thrust.

The designation 4-1 means that four of the M-1 engines would be used in the stage, and it would have an engine-out capability. This means that if one of the liquid engines were to fail for any reason it could be shut off and the remaining three engines would carry through the mission.

The NASA in-house activities are now underway at Marshall Space Flight Center to analyze the many aspects of the design and handling of vehicles like these.

The first job that Marshall will do is to specify in detail the burning time and thrust characteristics of the solid-propellant motors, to meet the limitations of the liquid motors and stages, the manned payload, and the guidance system.

This is obviously necessary because the solid motors and the stage made of the solid motors must not produce excessive acceleration loads on the men in the space capsule.

The motors must burn a proper length of time, so that the aerodynamic forces produced by the high velocity through the relatively dense low atmosphere are not great enough to crumple the relatively fragile upper stages.

NASA has also established a number of contracts with private industry to work out the details of stage design, interstage design, and the handling, transport, and launch problems.

The Boeing Co. at Seattle, under contract NAS 8-2438 has been working in this area for about 9 months. They will tell us the ideal stage weight, the best structure for holding the motors and for joining the solid stage to the liquid stages, and they will tell us how to assemble the vehicle and launch it.

An important part of their work will be to assess the cost of doing various things, and thus to find the lowest cost commensurate with the high reliability we need for manned space missions.

The next three slides illustrate some of the considerations involved in a system study such as Boeing is making. Here (fig. 21: Vehicle assembly I; fig. 22: Vehicle assembly II; fig. 23: Vehicle assembly III), we see the steps in a possible method of assembling a stage of segmented solid motors and mating the stage with the rest of the vehicle.

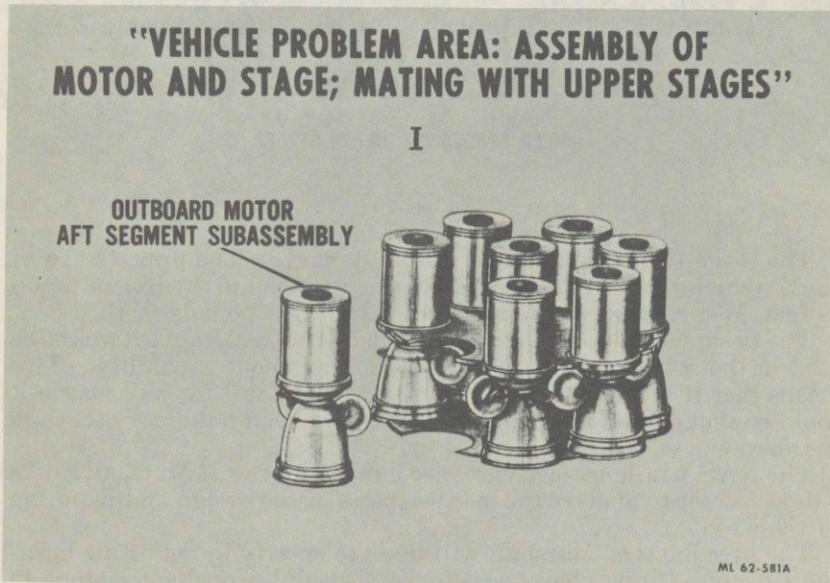


FIGURE 21

**"VEHICLE PROBLEM AREA: ASSEMBLY OF MOTOR AND STAGE; MATING WITH UPPER STAGES"**

II

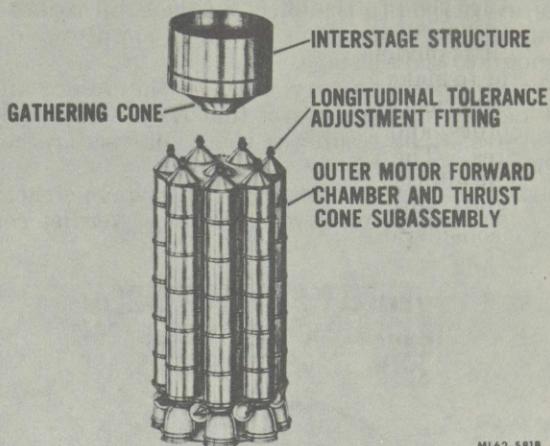


FIGURE 22

**"VEHICLE PROBLEM AREA: ASSEMBLY OF MOTOR AND STAGE; MATING WITH UPPER STAGES"**

III

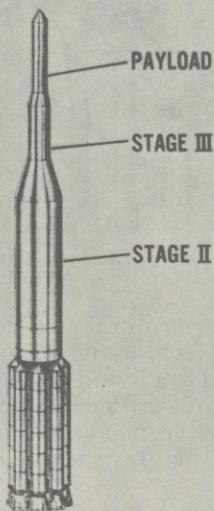


FIGURE 23

Needless to say, these are examples only, and we must wait for the completion of this contract and the others I will describe in a moment, before we are sure of the best method.

The Aerojet-General Corp. has been working under contract NAS 7-152 to analyze the problem of the cluster structure of a solid propellant stage in relation to the effect on the solid rocket motor.

I am sure it is obvious that one cannot simply weld a steel beam to a rocket motor to make a stage.

Aerojet's experience is very great in the design and manufacture of rocket motors, and we expect that they will establish the critical design features. The results of their analysis are continuously fed into the Boeing effort.

The next slide (fig. 24: design of interstage structure) illustrates the kind of consideration involved in the Aerojet contract.

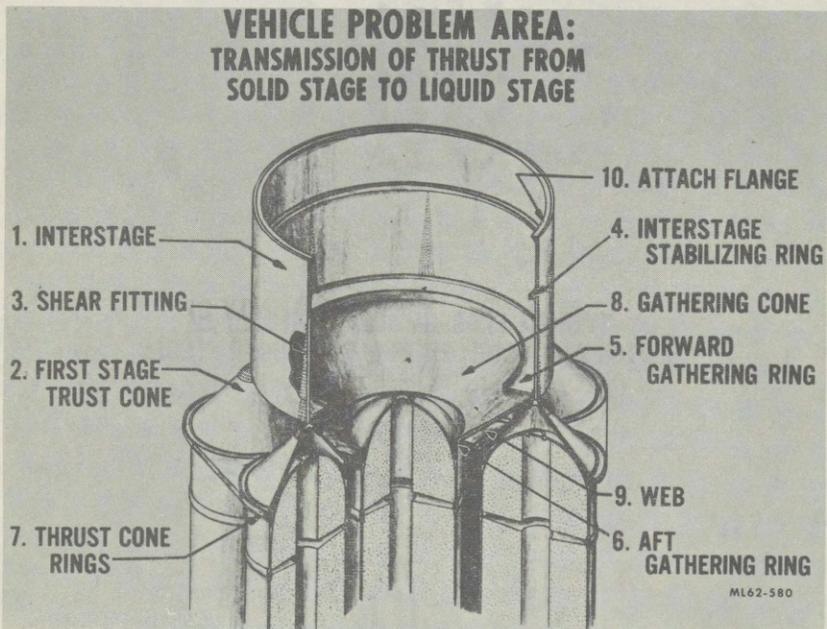


FIGURE 24

The specific problem illustrated here concerns the method of transmitting the thrust from a number of rocket motors to the interstage which will then lead to a liquid propellant stage.

Some of the technical difficulties involved arise from the fact that it is almost impossible in normal fabrication technology to make a number of large structures such as rocket motors, with exactly identical lengths.

The normal tolerances of manufacture make this impossible. In addition, the ignition of the motor and the subsequent burning produces a pressure in the neighborhood of 700 pounds per square inch inside the motor. This causes the case to stretch.

All of the motors in a cluster do not stretch the same amount because they cannot be made with exactly the same metal thickness nor do they operate at exactly the same pressure.

Furthermore, just to make the problem more interesting, the motor cases will swell or increase in diameter when the pressure rises. Some provision must be made for that.

Aerogjet's contract studies this situation in great detail and will finally tell us the best clustering design in terms of minimum weight, minimum cost, and, of course, least effect on the rocket motors.

Another contractor, the Lockheed Propulsion Co., is doing somewhat similar work. Their study is limited to smaller solid propellant stages which might perform the mission I illustrated earlier, for delivering about 35,000 pounds into orbit.

Just recently, NASA awarded two new NOVA system study contracts. One went to General Dynamics/Astronautics Division and the other to the Martin-Marietta Co.

The objective of these contracts, which are the normal prelude to any system development work, is to define in detail the best approach to performing the NOVA mission.

These contractors will give full consideration to solid rocket motors in their studies.

Another contractor, Stanford Research Institute, under contract NASr-49(05), is delving into the potential hazards that might be involved in using solid propellant motors or stages which could contain almost 12 million pounds of propellant.

This is an extremely important effort. It will tell us how far launch pads have to be separated. It will tell us how far the control rooms and other inhabited buildings have to be separated from the launch pads, and will tell about the kind of construction.

It will define the method for receiving and checking out motors at the launch base. It will try to predict what would happen if one of the liquid propellant stages were to fail for any reason, exposing the solid propellant stage to fire and shock. This contract is quite obviously important to the vehicle launch system.

We have in the past supported other system contractors, and we are preparing tasks now for bidding. The NASA effort, in analyzing and defining the programs, will intensify and will lead to experimental programs for proving out structures and stage dynamics.

Both NASA and Air Force have supported and will continue to support a number of programs in areas of solid rocket technology. NASA supports approximately 30 of these.

I will illustrate a few of the programs of greatest importance to the use of the very large solid motors I have just described.

This slide (fig. 25: Example of supporting programs: Secondary injection vector control) shows the method for obtaining steering force on a vehicle by injecting a fluid into the rocket nozzle.

The fluid may be an inert substance like freon, or it may be more energetic and reactive. Whatever the material, it is injected into the nozzle when the guidance system of the vehicle calls for steering forces.

The big advantage of the secondary injection system is the fact that there are no components exposed to the very high temperature (over 6000° F.), and high velocity of the exhaust gases of the rocket motor.

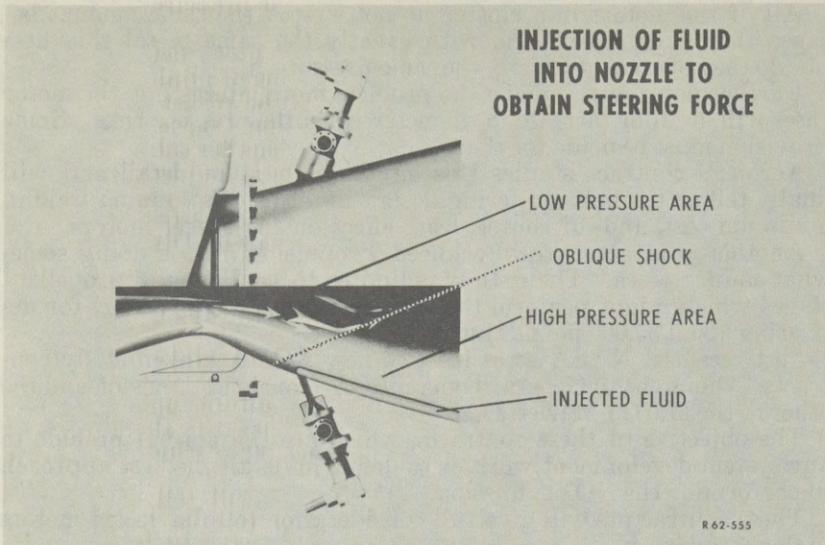


FIGURE 25

This method for obtaining what is known as vector control has been brought along rapidly by both NASA and Air Force programs, and it is currently one of the more attractive systems for vehicle use.

Here (fig. 26: Comparison of vector control system) we see illustrations of three methods for obtaining steering force by changing the rocket thrust direction.

At the left is the liquid injection method I just mentioned. In the center is a gimbaled nozzle, which is designed to move or deflect by as much as  $8^\circ$ , with a corresponding buildup of side force.

This kind of nozzle is very well established in smaller rockets, and would have many advantages for the large stages required for space launch vehicles.

It must be tested for the long duration and at the high thrust level typical of the motors for space vehicles. The illustration at the right shows a nozzle with jet vane deflecting the hot gases. This is a system widely used in rockets with relatively short burning times, but it does not seem especially attractive for the large, long burning motors because the vane ultimately will be worn away by the high-temperature exhaust.

A very important area of technology we are investigating, through two contractors, Aerojet-General Corp. and the Thiokol Chemical Corp., relates to the safety of the astronauts in the space capsule.

We know that failures of motors can occur, in spite of the most careful preparation and inspection. Some warning must be given of impending failures and some mechanism must be established to operate the capsule escape system.

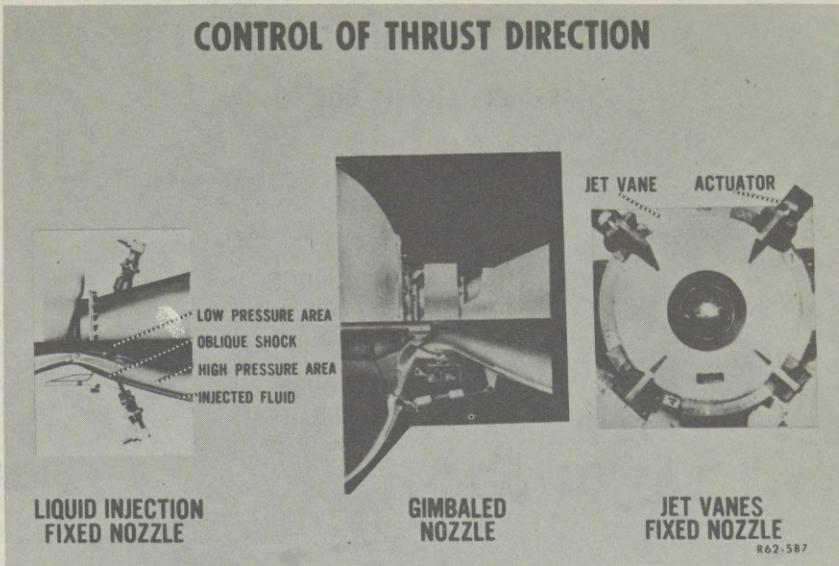


FIGURE 26

Figure 27: Example of supporting programs—Failure warning system: The two contracts which have been underway now for more than 6 months are designed to do this.

They will tell us the kind of instrumentation to put on the rocket motors to give warning of failure, and will try to establish the electronic package needed to feed the information to the vehicle brain.

This failure warning system for solid motors and stages is analogous to the system already developed and employed in vehicles which use liquid propellant stages.

As you might conclude, the development of this system is of utmost importance since it is essential for any manned mission.

In conclusion, I want to say a few words about the coordination between NASA and Department of Defense.

You are aware that part of the program we have just described is carried out directly by NASA or NASA contractors, and part is carried out by the Department of Defense.

You know that the major funding for the demonstration program, which is the most expensive part of the total job, comes from Department of Defense funds.

We have established what we and the Department of Defense believe to be the most efficient and uncomplicated coordination method to define and carry out the program.

The Air Force Space Systems Division has been assigned the responsibility and authority for carrying through the joint effort.

Within NASA, the Solid Propulsion Office in the Office of Manned Space Flight has been given similar authority and responsibility.

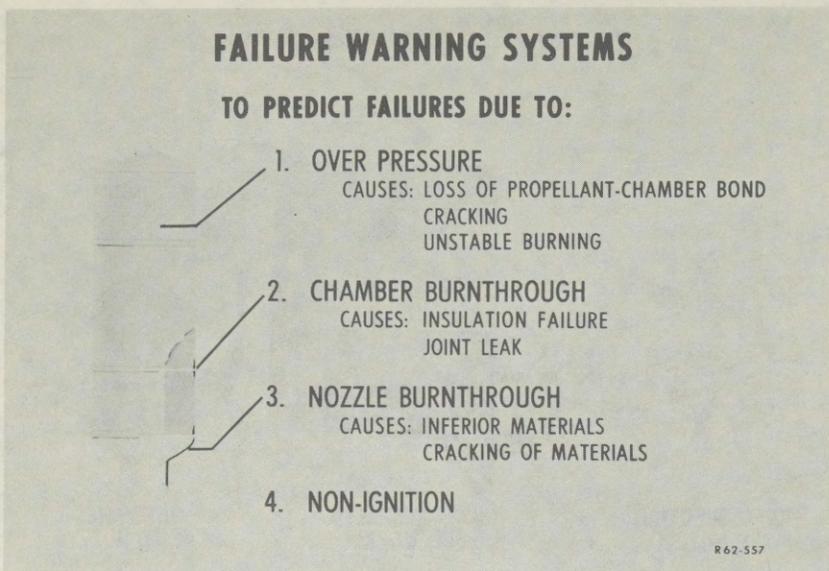


FIGURE 27

These two organizations work directly with each other to try to establish the best program. We find fine cooperation from the Space Systems Division, from the other Air Force people at Edwards Air Force Base, and from the people in the Aerospace Corp., a contractor to Air Force.

The plans and programs that are developed by this coordination are generally reviewed within NASA in the Office of the Associate Administrator, within the Air Force Headquarters organization, and finally within DOD in the Office of the Assistant Secretary for Research and Engineering.

In reviewing the coordination items during the past year, we find that we have been in contact with Department of Defense or Air Force on the average of twice per week and on numerous occasions we have spent extended periods at the west coast.

As mentioned earlier by Mr. Dixon, our planning and coordination efforts with the Department of Defense are presently concentrated on defining a detailed program that is mutually acceptable to NASA and the Department of Defense and is in the best interest of the Nation's space effort.

Mr. KING. Thank you very much. At this time I would like to ask several prepared questions, the answers to which you have partly covered already in your prepared statement, but perhaps you could repeat again and direct your answers specifically to the questions.

Reference is made to the national large solid propellant rocket program presented to the committee during the NASA authorization hearings.

Would you please review this program and indicate what progress has been made to date.

Mr. DIXON. Yes, sir.

You recall that Mr. Cohen did cover some phases of this here, and as previous charts indicated, that we would have in the near future our demonstration firings of 100- and 120-inch segmented motors.

With respect to that program, this has been carried out. Since our last hearing very successful test results have come forth from this in the 100- and 120-inch diameter sizes.

I had the opportunity to witness some of the tests on the 100-inch and I thought these segmented firings were a major milestone of accomplishment in this country.

This is a real step forward from what we accomplished in the previous year in the 100-inch diameter size, in that we have increased the number of segments, and increased the diameter of the motor from 100 to 120 inches with the resulting increase in the thickness of the web of the motor.

This is another step forward in the really basic data we need to proceed to the feasibility demonstration of the larger motors.

As shown on the chart, which is the same chart that Mr. Cohen showed you, it tells the growth of the national solid propellant program. As you can see (indicating), here we have a series of steps in technology that we have been able to accomplish in this country. Looking to the future, as shown by the chart, the proposed next step would be in the larger diameter segments as well as the monolithic structure at the 22 feet diameter level.

The thing that I would like to point out, is that in the next step of the program that we are now studying in detail, is the amount of propellant is tremendous for one firing. It takes possibly a month to accomplish the propellant pouring, and one of the firings would possibly cost in the order of \$15 million just for the ingredients and effort going into the casting, without counting all the supporting research and engineering effort that goes before.

Thus, we have to be very wise in our planning and in getting the most result for our country.

Mr. PEACOCK. On the first chart, would you give us a breakdown indicating what plans have been made for the commitment of these particular funds, and particularly the 20 million for the 156-inch and the 20 million for the 240-inch?

Mr. DIXON. I would like to point out that these charts, of course, are informal charts, prepared for the discussions with the committee. I can talk in detail with you, with respect to NASA's funding, but with respect to the Department of Defense, I would like to suggest that, since they are in the formulation of their funding, they could discuss this better than can I.

Mr. PEACOCK. In a recent article in the press, the indication was that the 156-inch and 240-inch have been dropped from the program.

If this is true, would you please give us the new program objectives, especially for development of motors above 120 inches.

Mr. DIXON. Let me cover NASA's activity first and then talk about the demonstration program, if that is satisfactory.

Mr. PEACOCK. Yes.

Mr. DIXON. With respect to NASA's effort, we had proposed in the President's budget approximately \$5 million to do studies related to the application of large solid rockets to launch vehicles. I think,

the type of studies that we propose were fairly well covered in our statement to you.

In 1963, of course, your funds have not yet been made available and we do not know how much we will get. We do have contracts already underway in this area. The extent of how much money would be available we do not know.

Mr. PEACOCK. This is the first \$5 million you are referring to?

Mr. DIXON. Yes.

Mr. PEACOCK. Inhouse NASA money?

Mr. DIXON. Yes. That is for the vehicle and mission studies.

Mr. PEACOCK. All right.

Mr. DIXON. In terms of the \$5 million listed for the advanced technology, this type of effort involves details that we have brought forth in my statement.

These things can include studies of new nozzle concepts, failure criteria of materials, low pressure combustion studies, space environmental effects, hazardous classifications of large motors, thrust vector control system studies and experimental work, large motor inspection concepts, and hot gas valves that might be needed.

It is subsystem research work that would be carried out that is applicable to improving the technology of the large solid rocket motor irrespective of the type, whether segmented or monolithic.

This is proposed in the order of a \$5 million level of effort for 1963.

Mr. PEACOCK. Alluding to the prepared statement, in which you state the NASA program objectives for large solid motor development; now do I understand you to say there is no money in the NASA 1963 program to meet these objectives? It is the committee's understanding the funds shown here in the DOD budget were programed to meet the NASA objectives as well as the DOD needs. We would like to know what assurance NASA has from DOD that the program objectives for development of the 156-inch, 240-inch, and 260-inch solid propellant motors will be met?

Have you established joint plans with DOD to accomplish these objectives, and what agency would be responsible for budgeting and funding those particular programs?

Have there been any recent changes? What are the plans to date?

Mr. DIXON. We are, as I mentioned before, working on the details of the program concept and exact level of funding. We have not really come up with a total cost of these programs. In some cases we will not know of the magnitude of the program until we get bids back from the contractors.

Mr. PEACOCK. Have proposals gone out for these particular programs?

Mr. DIXON. To my knowledge no proposals have gone out although numerous discussions are underway with various potential contractors, or bidders, in order to get their concepts and ideas of the program.

I believe that the Department of Defense and the Air Force could best tell you the magnitude of the program. As you recall, General Schriever did present his statement and he indicated that it was proposed at a level of about \$40 million for the advancement of large rocket motors in fiscal year 1963.

Mr. PEACOCK. \$60 million was his testimony.

Mr. DIXON. \$60 million—I'm sorry. I thought it was \$40 million.

Mr. PEACOCK. Sixty.

Mr. DIXON. Yes, sir. We are proceeding with the detailed planning of our programs. There are a lot of factors you have to consider in really formulating a program.

For example do you simulate a length of charge of, say, 130 feet with a small size, which would be an inexpensive approach, in order to get the test results you need for the ignition of a large charge?

This may save millions of dollars.

As I pointed out, when we fire one of the large motors, it can have a total dollar value, just for making the motor, of \$15 million.

This is an important part of the program that we have to consider. We must get the maximum amount from each experiment. Accordingly, when we do one of these demonstration firings, we want to make sure that it will add importantly to the technology which is under development.

Mr. PEACOCK. One of the items that has given the committee concern is a recent announcement in the press which stated DOD does not intend to go any further than the 120-inch as far as their program is concerned. We understand the Air Force is ready and able to carry out NASA's requests and requirements for 156- and 240-inch solid motor development but to date the funds have not been released by DOD.

So it is a matter now of how these programs are going to be funded if this money, in the Air Force budget, is not going to be utilized for this particular purpose?

I notice in your prepared statement you stated that there was an Air Force responsibility not only to supervise and manage the program but also fund the program. It appears here that the Air Force did budget \$40 million to meet these objectives for the large diameter motor development program, but now we understand they are being prevented by NASA and DOD from utilizing this money. Is this true, is DOD holding the Air Force back from funding this program for you?

I understand there are no military requirements; these are strictly NASA requirements for this development.

Mr. DIXON. Sir, I am confident that we can work out with the Department of Defense a mutually acceptable program for this next step in the development of the large solid rocket technology.

I don't know where this public information comes from.

Mr. PEACOCK. I have no indication—

Mr. DIXON. I don't know whether the Department of Defense made a statement that they are not going to do any work in this next area of activity on large solid rockets.

Mr. KING. Let me inject a question there.

You say you don't know whether they have made that statement.

Do you know positively that they do intend to go ahead with the 156, 240, and 260 program?

Mr. DIXON. I guess the best way I can answer is that we are in the process of making a detailed analysis of the type of program needed to further the technology. The 156- and 260-inch diameters are the sizes we are reviewing to determine the types of experiments that we would like to perform.

Mr. KING. When we had hearings on this a few months ago, the understanding was that the Air Force was to activate and carry out this program, which was essentially your program, but which they are better equipped to carry out than you; is that not correct?

Mr. DIXON. Yes.

Mr. KING. And the understanding was further reached that you would exercise close supervision and monitor their program, so that you would know at all times what was going on, and if at any time you felt that progress was not being made sufficiently quickly to meet your program objectives, that you would immediately confer with them, and if the matter couldn't be resolved, that you would come back to the full Science and Astronautics Committee and make that fact known so that perhaps further assistance could be provided by the committee.

Now is that still your understanding?

Mr. DIXON. Yes, sir. Of course, we would have to examine all the program aspects at NASA, and certainly come back to you and review the situation. I am confident that we are actually on the way to establishing a detailed program for these large motors.

This does take time, but I think the time is well taken in that we are using all of the experimental results that were obtained during this spring and early summer. We are also feeding in results from the studies that we have been making in order to help formulate the program.

I am confident that in the immediate future we will have arrived at a real master plan of the experimental program.

Mr. KING. Mr. Dixon, let me refer you again to this 156- and 240- or 260-inch program, and I would like to ask the question specifically, because the answer that you give to this question will constitute the basis for questions that we will ask the Air Force when we discuss the matter with them. So let me ask the question again.

According to your knowledge and understanding what is the present status of the 156-inch and the 240- or 260-inch program? What is the status of those two motor development programs?

Mr. DIXON. The status is that we are now in the process of reviewing the approach to these programs in terms of the experimental endeavor that is to be carried out. Before we go to the contractors and ask for bids we must have a really good concept for the program. This requires effective laying out of the experimental work and supporting research that must be performed. It involves the concept of the design of the experiment and the detailed planning of the program.

We must do this, because if we merely ask for general bids to do something in a general manner, we might find after a year or two that we have made a mistake and have wasted a lot of funds.

Mr. KING. Mr. Dixon, are you satisfied that progress is being made in working out these plans and concepts that you are talking about?

Mr. DIXON. With respect to NASA and Department of Defense, I am satisfied that we are making progress. As an engineer, of course, in new things, I am never satisfied, because engineers are curious and they are always unhappy until they see something done. With respect to our planning and working, I am satisfied that we are proceeding and confident we are arriving at our master plan.

Mr. KING. When you say "we," are you referring to NASA or the Air Force?

Mr. DIXON. I am referring to NASA.

Mr. KING. NASA.

Mr. DIXON. Yes, sir.

Mr. KING. Are you satisfied that when these basic concepts that you are talking about are properly formulated that the Air Force will go ahead and carry out its side of the understanding that was reached, or do you anticipate some roadblocks in that area?

Mr. DIXON. I am satisfied to date. I am confident that we will arrive at a program with which NASA and DOD and the Air Force are satisfied.

Mr. KING. If for any reason you should encounter roadblocks stemming from DOD itself—I say if you should—is it our understanding that you will come back to this committee, in accordance with the understanding that was reached several months ago?

Mr. DIXON. Well, certainly, first, I think we should review in NASA the overall situation. If we are not satisfied, then we are certainly obligated to come back to the committee and review the matter.

Mr. KING. May I pursue this one step further. Looking into the future what would be your estimate as to the amount of time that will be elapsed before you reach that point where these concepts are sufficiently formulated and that you can get right down to the business of activating this program?

Mr. DIXON. This is difficult to judge because of the complexity of the planning. However, I am confident that within the next 2 or 3 months we will have arrived at our plan.

Mr. PEACOCK. Mr. Dixon, from your prepared statement I understand study contracts with such organizations as Boeing, Aerojet, Lockheed, Martin, and General Dynamics have been awarded and these people are actually engaged in studying these problems to come up with answers. Is that correct?

Mr. COHEN. The answer is that two of the contractors, Martin and General Dynamics/Astronautics, have been selected from the competition for the so-called NOVA system. They have not signed a contract. They have been selected.

Mr. PEACOCK. Don't identify names. Two have been and the rest are still in the negotiation stage?

Mr. COHEN. No. These are the only ones, which we mentioned, that are not signed. I will run down a few—

Mr. PEACOCK. When do you intend to complete these study contracts and obtain this information so you can develop your master plan?

Mr. COHEN. The answer is, They are underway.

Mr. PEACOCK. Can you give us an estimate on a target date? Time is of the essence in the developing of a larger solid propellant booster. Will this delay the program further?

Mr. DIXON. Maybe I could answer this. One program underway studies solid boosted vehicles.

Mr. PEACOCK. This is not going to delay the motor development program, is it, as these studies are related to the NASA task of providing the booster after the engine is developed; is that correct? It is not related to developing motors per se.

Mr. DIXON. Correct. They are mainly related to the integration of the motor with respect to the vehicle—what are the actual concepts of integration, of clustering these motors, what are the problems of using these motors as vehicles.

They are proceeding. They are also helping in establishing the concept of what type of research and advance technology we should undertake with respect to motors.

Mr. PEACOCK. Then these studies will delay the motor development program; is that what you are saying?

Mr. DIXON. No. I think they are helpful because they are part of the overall picture.

Mr. PEACOCK. So if the Air Force said tomorrow, "We are ready to go," and funds are available, they could go on with the 156-inch and the 240-inch development, as these studies would not hold back any activity in this particular field; is that correct?

Mr. DIXON. I don't think they would hold us back.

Mr. PEACOCK. Is the motor the pacing item in the development of the large solid booster?

Mr. DIXON. There is a combination of areas. The motor is one of the most important factors, as you know, because it provides the thrust. However, to make it perform as a launch vehicle, as Mr. Cohen showed you on the chart, there is really a combination. You must control this whole vehicle through some means of deflecting the thrust or other control method.

You need also to package the whole guidance system that sends the signals for the control. You need all of this in combination with a structural capability to integrate the entire vehicle.

Mr. PEACOCK. What you are saying is that these two activities can go on concurrently.

Mr. DIXON. Let me put it this way: We know enough about the concept of large solid-rocket motors that we could get started on the research and the technology through firing demonstrations and in addition proceed with the concept of vehicle design.

It may be that somewhere down the line if you find the duration or thrust level is off, or maybe the whole motor is too heavy to meet the mission, you would have to go back and start a modified development.

However, the problems we visualize in the motor itself are best demonstrated by firings. As you know, the solid-rocket motor is assuming more of an engineering aspect, but still it is an art in itself. Proof of its capability to accomplish a job is the demonstration.

When you want to use a motor having a propellant grain 22 feet in diameter, you can't say "I have tested 4-foot-diameter motors, thus I am sure I can manufacture 22 feet." You must actually do it in order to see what the problems are.

Mr. PEACOCK. In summary, you say your studies will go on concurrently with the motor development and there is nothing to prevent the Air Force motor development from proceeding as far as NASA's work is concerned.

Mr. DIXON. We would visualize—what you call motor development—we visualize the kind of motor that is a concept of a demonstration of the size of the problems involved. It may not be that particular motor for application.

Mr. PEACOCK. The demonstration program is part of the motor development program and these demonstrations will continue to the point where you actually come out with the one that you are going to select and use in your large solid booster development; is that correct?

Mr. DIXON. Yes. This is the first phase, I would say. Maybe Mr. Cohen would like to elaborate on that.

Mr. COHEN. You must understand that when we have the temerity to call out a size or thrust level, this is the result of considerable analysis and study. It has gone on in one scale or another since 1959 under about 10 or so analytical programs and a certain amount of experimental work.

So there is a best opinion, as good as NASA can derive on the dimensions and weight. There is no doubt there will be feedback from vehicle problems to the motor.

It may be that the proposed way of holding a motor and transmitting its thrust to the vehicle does not suit the liquid propellant motors.

Therefore, there will have to be changes. These potential changes don't seem to be so fundamental that we must wait for this refined kind of definition.

Mr. KING. I would like to ask this question.

It is our understanding that the original agreement that you had with the Air Force covered the development of the large motors, which included the 120 inch, the 156 inch, and the 240 to 260 inch, which development would utilize the existing state of the art. If this is true, what has NASA done about initiating plans to advance the state of the art for even larger solid engines or advanced technology for the next generation, such as fiberglass and epoxy resin booster cases, et cetera.

Mr. DIXON. I think I would like to start off. Maybe Mr. Cohen will have something to add.

Certainly we are interested in advancing the technology beyond the state of the art today. One area in which we are interested and are discussing with DOD is a large fiberglass case.

We feel that this type of technological advancement is applicable to the large solid-rocket motor and will make a major advancement, especially in the mass ratio. The strength-to-weight ratio is a tremendous improvement over the best that we have today, as you know.

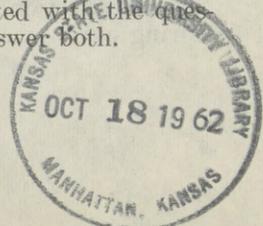
We are proposing a program in which a case would be built in the order of 20 feet in diameter and structurally tested to see what strength problems are involved.

Also we propose such a case to be sent to Marshall Space Flight Center for structural testing under vibration to see whether this condition causes problems.

This type of program is part of the detail that we are working on with the Department of Defense and Air Force. In our preliminary discussions with the Air Force and DOD, they think such a concept is very important and it should be pursued.

That gives you one area. In the areas of propellants, new concepts of nozzles, things like that, maybe Mr. Cohen would like to elaborate.

Mr. KING. One other question, which is associated with the question I just asked, and perhaps Mr. Cohen could answer both.



We understand that recently NASA started a research program in the field of fiberglass cases but canceled it due to objections by the Department of Defense.

If this is true, why was such action taken?

Mr. DIXON. Maybe I should answer that, sir.

Mr. KING. If you will.

Mr. DIXON. This particular program we were proposing is part of the total plan and is one of the details of advanced technology that we and the Department of Defense are reviewing to see how it fits into the total technology that we want to develop.

We haven't initiated a contract or received bids for such a program. At present we are holding off on this effort until we look at it with respect to the total plan.

Mr. KING. You are stating that this cancellation was not due to any judgment on the merits, but due to a matter of timing?

Mr. DIXON. That is right. That and how it fits into the program. We wanted to get several bids to see what could be done. We have not actually selected a contractor on this. We have held off on the awarding of a contract until we mapped out the master plan with the Department of Defense.

Mr. PEACOCK. What is your target date for completing your master plan?

Mr. DIXON. We haven't set any firm time.

Mr. PEACOCK. Do you want to make an estimate?

Mr. DIXON. I visualize within the next 2 to 3 months and maybe earlier. That would be the best guess that I could make.

Mr. KING. We notice the presence of the distinguished chairman of the full committee, Mr. Miller. Do you have questions, Mr. Miller?

Mr. MILLER. No, I am just down trying to gain some information. Thank you.

Mr. KING. Feel free to participate at any time.

Mr. MILLER. Thank you.

Mr. KING. Mr. Fulton.

Mr. FULTON. I came as a visitor, but I guess I am the Republican side this morning.

Mr. KING. As such, please take over.

Mr. FULTON. I have been disappointed in the progress of NASA through the development of solid propellants as well as the development of high energy propellants and nuclear propellants as well.

I still am discouraged, after hearing your testimony and reading your statement this morning.

The basis of my discouragement is this:

I find no set schedule for programing, for reaching various plateaus of accomplishment, that would lead us on to a development program.

My comment would be that we can discuss so much and plan so much, but we get very little done.

I might say parenthetically that I have justification for making this comment as I have had some experience in this field, as I was one of the Navy representatives on the aircraft scheduling unit in World War II at Wright Field with the Army Air Force, scheduling plane production for the Army Air Force, U.S. Navy, and the British during our tremendous expansion in early World War II.

We were always required to come up with plans that would end in production programs without just continuous modification of schedules and shipping target dates.

If you look at your statement, where you are speaking of the motor demonstrations program, on page 6, working with the Department of Defense, it is obvious from the first paragraph that you have reached no conclusion.

I will read it:

As stated previously, we have transmitted our requirements for this program of motor demonstrations to the Department of Defense—

My comment on that: You are a customer and have stated your specifications.

and are working closely with DOD and Air Force to establish the details of programs to carry it out.

That means that you are consulting closely with the DOD and Air Force to establish programs.

You state further:

We have had fine cooperation from the DOD to date—

I compliment you on that.

I read further:

to define a program which will be mutually acceptable to the DOD and NASA—

To translate that, it means that you hope to get a program but you haven't got it now, and it must then be agreed on by the DOD and by NASA, but to date there is no agreement. It is simply a hope that some program will be mutually acceptable to both, and then you hope—

to the best interests of the space program.

Now that doesn't say whether it is the NASA program, the military program, or the overall U.S. space program.

You say further:

We are presently working with the DOD in an effort to establish in detail a mutually acceptable program for review by higher authority.

Which again emphasizes that there is no approved program now, because you are going to try to establish it for review by higher authority.

The first steps taken must be to establish a schedule.

My criticism is, again, that your statements do not give us the timing, the levels of accomplishment of the program, nor the development of these various motors, configurations, fuels, or program funding.

I ask you the question:

What review by higher authority will there be, and how long will it take after you and the Department of Defense make up your minds what the program is?

Mr. DIXON. We are reviewing this at the highest level, Assistant Secretary of Defense for R. & D. and the Assistant Secretary of Air Force for R. & D. We feel that these types of programs should be reviewed in that level. The engineers of both Air Force and NASA are formulating the program and I think it is wise that you do have that level of people really look at the program in detail.

Mr. FULTON. How long would it take to get this review at higher level?

Mr. DIXON. That comes very quickly as part of the process. The Assistant Secretary, Air Force, and Assistant Secretary, DOD, and Associate Administrator at NASA have been in constant discussion.

Any time we evolve a program for discussion they make themselves available.

Mr. FULTON. Does NASA have adequate funds for a real program of research and development in the solid fuel and slurry fuel field?

Mr. DIXON. No. You are talking about the slurry fuels?

Mr. FULTON. In both solid and slurry.

Mr. DIXON. I would like Mr. Cohen to answer this.

Mr. COHEN. Mr. Congressman, you are asking us whether we have adequate funds. Funds are always short for these sort of programs so there is always a constant weighing of priorities and objectives.

Mr. DIXON. Yes.

Mr. FULTON. They are not always short, because I am not the only one on this committee that has put in an amendment to give NASA more money for solid fuel research. As a matter of fact, when NASA came in once with a justification for \$8.3 million, by amendment we increased it to \$18.3 million, \$10 million more than was asked.

I may say to you further, that this year on the high energy propellants it was my amendment that added a half million dollars more than you asked. Senator Kerr increased it to a million. So you are getting a million dollars more for high energy fuels, such as boron and fluorine. I have a real point as to what is the problem here and why the failure to get moving.

This solid propellant field is not new. Some of us have watched it develop over a period of years. We in the U.S. Government have two very fine solid fuel rockets right now—POLARIS and MINUTEMAN.

We have given it tremendous study. They are successful. They are good in performance. We certainly compliment the people that did the job.

But the time comes when you must stop planning, studying, negotiating, and going to higher authority and come up with some specific plans and programs of development, that will give us end results.

If I have any comment of criticism on your statement it is that the planning and reviewing is not producing a program. I want action.

Mr. DIXON. Mr. Fulton, I would like to point out—I don't know whether you heard the first part of our statement—we have since last February accomplished major advances in the growth of large solid rockets in the 100- and 120-inch diameter sizes.

Certainly with respect to the high-energy propellants, we feel this is a very important field. As you recall, we did have a hearing here on high-energy liquid rocket propellants.

Mr. FULTON. I know that in your 1962 budget you only used \$200,000 for research and in high energy propellants—which is nothing.

Mr. DIXON. We do feel that they should proceed with work on the new types of propellants.

Mr. FULTON. I want a broad base program of boosters, engines, and propellants that we in the United States then can use on a selection basis to meet our mission requirements.

My other criticism is that we are just piling cans on cans.

Unless we have these broad base solid programs moving so that you are developing them equally with the liquid propellants, I think we are making a tremendous mistake in our space program.

My feeling is that we know enough about solid fuel propellants that you people should be further along the road of development than you are.

When I hear the comment now that you don't have enough money, my comment is you certainly are a little late in telling us. We have had the NASA 1963 program passed 342 to 0 in the House which included everything you asked for on the current authorization.

I hope that you will go back over your program and, with the chairman's permission, I would ask you to come up with some target dates, some schedules of where you will be at certain times. Give us the figures that you will need for an adequate program in the solid fuel and the slurry fuel fields.

Likewise, I think that your program should include the high-energy propellants, and if a million dollars is not enough, for Heaven's sake, you have a committee in Congress that, for once, is saying to you, do an efficient job, but do the basic research necessary. This is the Science Committee.

We are not in the military field where there has to be an end item or weaponry system. We have the jurisdiction of basic research and development in the field of science.

I would have another criticism—which I would make to Mr. Dixon, that on the nuclear propellant program I don't think you have enough reactors. I think that is your limiting factor, and that you should let us know what you need.

But this thing of coming up here and being indefinite and consulting back and forth with various departments and bureaus and then not giving us something solid that we can plan on, or justify on the floor—I honestly hope that you will consider these suggestions, in all good humor, and as, maybe, a big boost to get you moving.

That is all, Mr. Chairman.

Mrs. RILEY. Mr. Chairman.

Mr. KING. Mrs. Riley.

Mrs. RILEY. Mr. Chairman, in the marital world we sometimes have a triangle. We have a triangle here, Mr. Dixon, the DOD, Air Force, and NASA. Now, do you anticipate making that triangle a happy one for the space program as far as it comes to exchanging technological findings and your moneys?

I want a happy solution.

Mr. FULTON. Being a bachelor, I am not in on this triangle.  
[Laughter.]

Mr. KING. May I say that bachelors very often are in on them.  
[Laughter.]

Mrs. RILEY. I do hope for a happy solution to that triangle. There seems to be doubt. I hope it can be resolved for the happiness of this

country and for our program. Right now it seems to me that they are poles apart—certainly financially.

Mr. DIXON. Mrs. Riley, I feel, and believe, that we do have a happy triangle. In fact, we are working together every day. We are certainly depending on the U.S. Air Force and the Department of Defense as an integral part of our overall program and our national space program.

We have our get-togethers and discussions of details of programs and plans.

Mrs. RILEY. Is the memory of these discussions a happy one at night?

Mr. DIXON. Yes. To me it is.

Mrs. RILEY. That is what I wanted to know.

Mr. DIXON. Yes, ma'am, they are very happy.

Mrs. RILEY. That is fine. Then we are moving along.

Mr. DIXON. Yes.

Mrs. RILEY. Thank you, Mr. Chairman.

Mr. KING. Thank you, Mrs. Riley. We have just 15 minutes.

I should like to read a few sentences which I expressed at the time of our hearings on March 7. I want to read them again because these sentences express today, as they did then, my feeling about the matter, and helped to orient us on what our objectives were then, for the purpose of seeing to what extent we have reached those objectives now.

Mr. FULTON. May I be excused to go to another committee meeting?

Mr. KING. Yes, we appreciate your very valuable comments, Mr. Fulton.

Page 1301, bottom of the page, I said:

I would like to say also that I have some concern myself about this transfer of responsibility to the Air Force. I will be interested in reading your further answer as to how this came about. It occurs to me, or seems to me, there is something basically wrong there because I don't see how the Air Force is going to have the proper motivation. After all, their function is to help safeguard or to protect our country from a military point of view.

Theirs is entirely a military mission.

Getting to the Moon is not a military mission. It is true there may be some military implications and there is a lot of literature on that.

At least our official position as of now and in the foreseeable future is that anything we do in outer space is strictly nonmilitary. Outer space is for peaceful purposes.

The National Aeronautics and Space Administration is the agency that is charged with carrying out this nonmilitary, this peaceful mission into space. Getting to the Moon is the very heart and core of that mission. That is our big target. We are in a race with the Russians, and this, I think, we have admittedly officially, as well as in a lot of unofficial literature.

So if we turn this over to the Air Force whose responsibility is our defense, not beating the Russians to the Moon, I wonder myself whether they are going to have the proper motivation. This is your responsibility, it seems to me, and not theirs.

I can understand you using their technology. They are experts in this field. They have developed the MINUTEMAN and the Navy has developed POLARIS, and they have some know-how in this field. I can well understand your using it. The thing that puzzles me is why you should turn over the main responsibility for vigorously pursuing this program when it seems to me that Congress and the law has made it very clear that that responsibility rests at the doorstep of the National Aeronautics and Space Administration.

And in answer to that your comment was that you have every feeling that the Air Force is properly motivated, that they are en-

thusiastic—you used the word “enthusiasm”—and you have no question in your mind but what you would get complete and adequate cooperation from them.

Let me read just one other paragraph that I stated then, on page 1303.

Last year I had the distinct impression from what President Kennedy said in his state of the Union message as it was supplemented by other messages, I had the distinct impression that we were to pursue a parallel course of R. & D. in both liquids and solids. I wouldn't say \$14 million compared to the hundreds of millions that have gone into liquid is exactly a parallel course of development. I wonder if what has actually happened in practice has been carried out in good faith.

Those thoughts were expressed and placed in the record at that time.

Now, Colonel Peacock would like to direct a few more questions in the remaining 12 minutes that we have to see if we can't pull this together and come out with some definite understandings in terms of dates and programs.

Mr. PEACOCK. With the chairman's permission I would like to ask NASA to submit for the record their master plan—as soon as it is completed.

Mr. KING. Would that be possible?

Do you see any objection, Mr. Dixon, from your point of view?

Mr. DIXON. I don't think so when the program has been completed.

Mr. KING. Without objection it will be so ordered.

Mr. PEACOCK. In summary, it is my understanding that NASA is going to go ahead with their study contracts with these five or six corporations on the systems integration and the booster development which would be more or less a parallel activity to the large solid motor developed program. At the present time NASA is relying on the U.S. Air Force to carry out the objectives, as originally outlined during the NASA hearings, to carry forth the development of 156-, 240-, and 260-inch motors, at least through the demonstration program. After that has been completed NASA would utilize those portions of the motor development program applicable to the particular missions NASA has at hand to carry out space exploration.

Is that correct?

Mr. DIXON. Sir, we are looking at what these applications might be. As you know, our program for the manned lunar program at present uses the C-5 and various upper stages. These are liquid chemical rocket systems. In terms of our choice for the program, we have selected this development plan to accomplish this particular mission.

Of course, as NASA's missions in the future change they may become more ambitious and, as time proceeds, we must look at other types of propulsion devices.

Mr. PEACOCK. Do you need a mission requirement as far as the development of these large solid-propellant motors such as 156, 240, and 260 inch are concerned?

Mr. DIXON. As far as going through our demonstration program, we do not see we need a mission requirement.

Mr. PEACOCK. You would apply this to the mission at a later date, if and when the mission is established, is that right?

Mr. DIXON. Yes. That is the purpose of our advanced technology program.

Mr. PEACOCK. Along this line, there is a NASA policy statement that—I imagine it is out of date, but for the record, I would like to read it—and I quote—

for solid and liquid rocket engines, the NASA plan is to place first reliance on large liquid engines and to monitor the development of solid rocket engines by the Air Force for possible use in NASA launch vehicles.

I understand now your position is slightly changed. If the solid motors pan out through these demonstration programs, they could compete on an equal basis with the liquid systems, is that correct?

Mr. DIXON. First, as I did explain, we have made a development choice for the manned lunar program, to proceed with an orderly, vigorous program to meet the schedules and objectives set forth by our President.

In terms of the solids, we see a continued advancement in the technology of large solid rocket boosters.

Over a period of years there will probably be need for new boosters, and there may be need for an additional size of vehicle for even the manned lunar mission.

Mr. PEACOCK. This statement is really outmoded?

Mr. DIXON. The statement, I think, is outmoded.

Mr. PEACOCK. One other thing, Mr. Dixon. Have you had any indication from the Department of Defense or the Air Force that they are not going to develop the 156-, 240-, and 260-inch motors to meet NASA's objectives?

Mr. DIXON. I would like to question your word "development."

Mr. PEACOCK. Carry it through the demonstration program.

Mr. DIXON. You carry it through and then fly.

Mr. PEACOCK. Have you any indication they are not going to carry out the demonstration programs as originally planned?

Mr. DIXON. I am confident that the program at which we arrive will be satisfactory to both parties.

Mr. PEACOCK. You have no indication they are not going to do so?

Mr. DIXON. No; I don't think so. I think we will have a mutually acceptable program for the country.

Mr. KING. On that one point, there is no question, is there, in the Air Force, about what your own feelings are on this matter?

You have made it abundantly clear to them that you consider this part of your program; is that correct?

Mr. DIXON. Yes; we have made it clear to them. In our discussions we have made it clear that these are objectives of advanced technology which we think would benefit us in the future. The Air Force and DOD, in trying to formulate this plan, are certainly going about it in excellent spirit and cooperation.

Mr. KING. Chairman Miller, do you have any questions?

Mr. MILLER. No.

Mr. KING. Mr. Dixon and Mr. Cohen, again we are very, very grateful for your presence. We have thrown a lot of comments at you. We still have 4 minutes. Do you have anything final that you might add, perhaps to try to gather in some of these comments and put the cap on your statement?

Mr. DIXON. Well, I just would say, I am certainly confident, as I said before, that we will have advanced technology program in solid rockets in these large sizes. I am confident we can work this out with the Department of Defense.

I have a personal interest in large solid rockets. Twenty years ago I was making them for the country. I am glad to see that over the last 20 years this country has made the progress that we have today.

I hope we continue it.

Mr. KING. I might add, Mr. Dixon, that personally we feel that you are one of the most qualified men in the Nation to be where you are and to be here before this committee today, and the committee is grateful for your coming here and for your very fine and lucid testimony.

If there is nothing further this subcommittee will stand recessed until tomorrow morning at 10 a.m.

(Whereupon, at 12 noon the hearing was recessed, to reconvene at 10 a.m. Thursday, August 9, 1962.)

The first part of the report is devoted to a description of the work done during the year. It is divided into two main sections, the first of which deals with the work done in the laboratory and the second with the work done in the field.

The laboratory work was carried out in the following order: first, the preparation of the various reagents and solutions; second, the determination of the various constants; and third, the determination of the various properties of the various substances.

The field work was carried out in the following order: first, the determination of the various constants; second, the determination of the various properties of the various substances; and third, the determination of the various constants.

## DEVELOPMENT OF LARGE SOLID PROPELLANT BOOSTERS

THURSDAY, AUGUST 9, 1962

HOUSE OF REPRESENTATIVES,  
SPECIAL SUBCOMMITTEE ON SOLID PROPELLANTS,  
COMMITTEE ON SCIENCE AND ASTRONAUTICS,  
*Washington, D.C.*

The committee met at 10 a.m., the Honorable David S. King (chairman) presiding.

Mr. KING. The subcommittee will come to order.

This morning the committee is meeting for the second hearing to review the large solid propellant booster program and will hear testimony from Gen. Bernard Schriever, Department of the Air Force, and Dr. Lawrence L. Kavanau, Defense Research and Engineering.

As you know, the purpose of these hearings is to review the program that was presented jointly by NASA and the DOD for the development of large solid propellants and boosters during the NASA authorization hearings.

General Schriever, we are vitally interested in obtaining your appraisal of the program to date and an indication of what your future plans are, not only to accomplish the objectives of the Department of Defense and the U.S. Air Force, but also to satisfy the NASA requirements that have been placed on the Air Force in this area, particularly for the development of the 156-inch and the 240- or 260-inch large solid-propellant booster motors.

We are also interested in knowing whether adequate funding has been made available to your organization to satisfy these commitments.

I note the presence—and I digress for a moment—of the Honorable Victor Anfuso, who is the permanent chairman of Subcommittee No. 2, and I would like to recognize him at this time.

Mr. ANFUSO. Thank you, Mr. Chairman.

I should just like to take this opportunity first to congratulate you for conducting these hearings. It is my opinion Congressman King is a very dedicated public official who is doing an outstanding job in the best interests of our country.

I know of his great interest in solid propellants, and I congratulate him for taking this initiative.

At the same time I should also like to greet my very dear friend, the witness today, General Schriever, who has always taken an interest in this field.

As a matter of fact, I think he was a pioneer in using solid propellants.

I hope, General Schriever, more good can be derived from these hearings and I know that you will continue your great interest in this field.

I congratulate you for it, sir.

General SCHRIEVER. Thank you.

Mr. KING. Thank you very much, Mr. Anfuso.

Perhaps at this time, General Schriever, I might quote just one sentence from the testimony of Thomas F. Dixon, Deputy Associate Administrator of NASA, who appeared before the subcommittee yesterday. I quote from his testimony:

Therefore, we have provided the Department of Defense and, specifically, the Air Force with our requirements for an advanced technology or feasibility demonstration program on large solid rocket motors pertinent to the development of solid rocket-powered launch vehicles.

This hearing this morning then I suppose would be an elaboration upon that one sentence, in which he indicated that requirements had been submitted to the Air Force.

By way of further historical reference, it will be recalled that when hearings were held in March of this year by this committee on the NASA authorization bill, the question of solid-fuel propellants was raised. NASA at that time submitted to the committee a schedule of funding, as they understood it, which was the result of an agreement or understanding reached between NASA and the Air Force.

The figure \$158.3 million was given to this committee as representing the amount of money which NASA and the Air Force would spend for research and development to further the large solid-fuel-propellant motor program, both in initial planning and R. & D. activities.

I believe at that time, General Schriever, you stated yourself, that you thought to do a complete job, a good job, on the demonstration of the 156-inch diameter motor and a demonstration of the 240-inch or 260-inch, as the case might be, that the \$60 million would be more realistic, although these figures that were furnished to us totaled only 40 million. Twenty million dollars for the 156-inch and \$20 million for the 240-inch.

The total figure, as indicated before, was \$158.3 million which included the two items I mentioned. Also included in this figure is \$73.3 million for the 120-inch diameter motor, 5 million for vehicle and mission studies, \$15 million for facilities, \$20 million advanced propellants for ARBA, and one or two other items, totaling \$158.3 million.

So we are interested this morning in knowing just what has happened in the intervening time and how this program is going forward.

If you have a prepared statement General Schriever, we would be very honored to hear it at this time. Otherwise, we have some questions.

General SCHRIEVER. No; I do not have a prepared statement.

Mr. KING. Would it be satisfactory then if we just started the discussion with some specific questions?

General SCHRIEVER. Yes, sir.

Mr. KING. Which in turn will undoubtedly lead to a fuller discussion even of items which may not be specifically covered by our questions.

General SCHRIEVER. Yes.

Mr. KING. Will both you and Dr. Kavanau answer the questions together or do we direct them to one and then the other—what is your pleasure?

General SCHRIEVER. You can direct them to either one of us if you would like.

Mr. KING. Why don't we direct the questions essentially to you, General Schriever, and at any appropriate point Dr. Kavanau can come in.

General SCHRIEVER. Fine.

**STATEMENTS OF GEN. BERNARD A. SCHRIEVER, COMMANDER, AIR FORCE SYSTEMS COMMAND, AND DR. LAWRENCE L. KAVANAU, SPECIAL ASSISTANT FOR SPACE TO THE DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE**

Mr. KING. Question No. 1: Reference is made to the national large solid propellant rocket program presented to the committee during the NASA authorization hearings which is depicted by the three charts before you. I believe you have been furnished these charts.

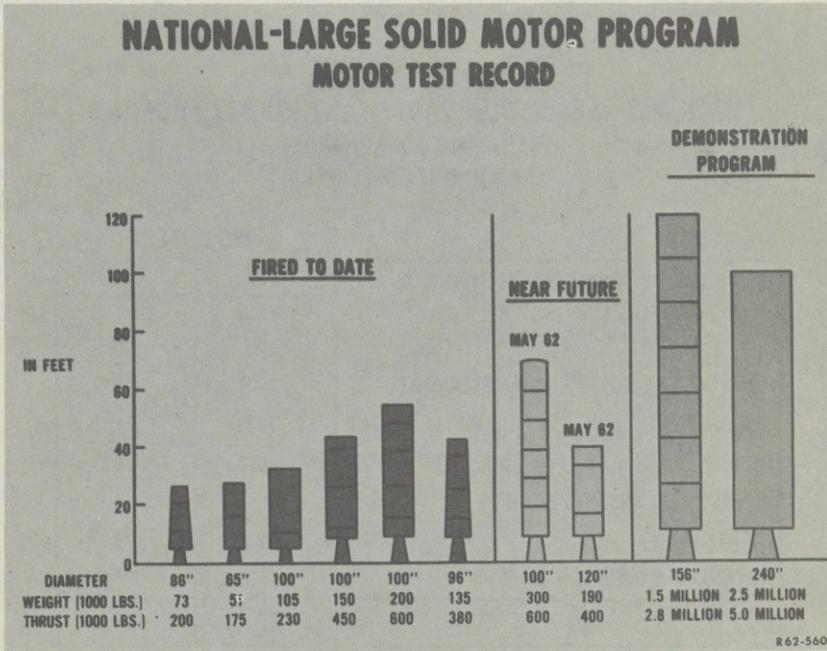


FIGURE 28

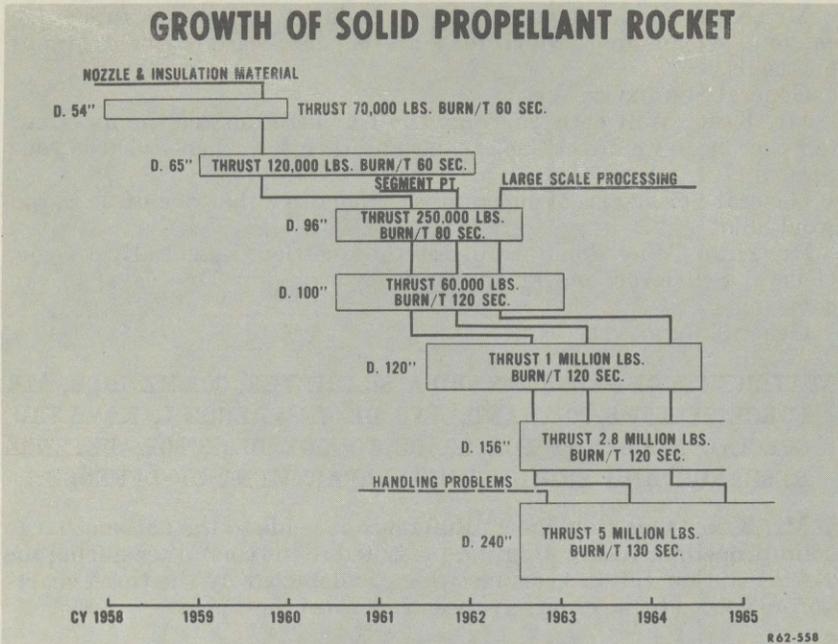


FIGURE 29

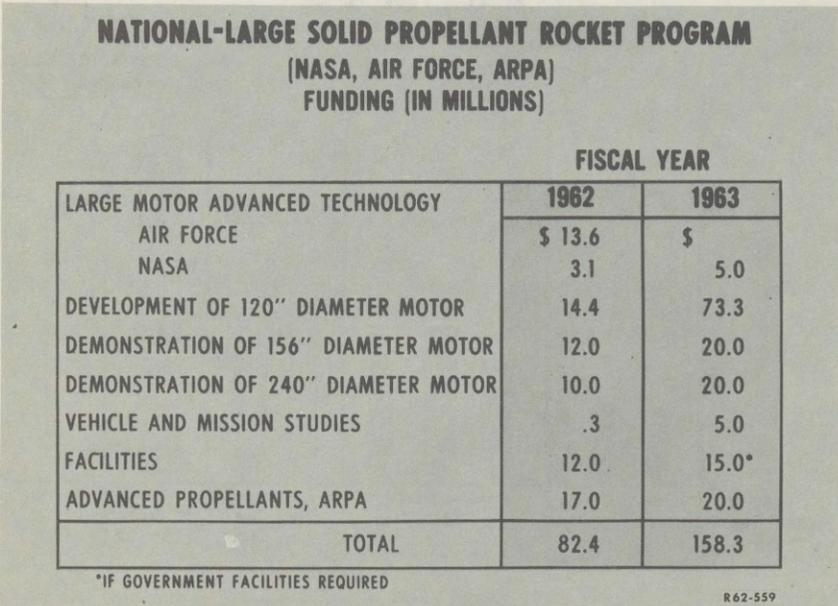


FIGURE 30

One chart is the one I referred to a moment ago, containing this figure \$158.3 million. The other two further elaborate on those basic figures.

Would you please review this program and indicate what progress has been made and will be made in the near future to accomplish the objectives envisioned by this program?

General SCHRIEVER. I might say this is the first time I have seen these charts, and I do not know when they were presented. When were they presented?

Mr. PEACOCK. Subsequent to the NASA authorization hearings, by Mr. Dixon, as the joint program that had been agreed upon by the Department of Defense and NASA to accomplish the objectives of a large solid propellant motor development program.

I think mainly, General, the two figures that the committee is most interested in are the \$20 million for the 156-inch and the \$20 million for the 240-inch, which in your March 1962 testimony you indicated, to do a program in this particular area, would require approximately \$60 million.

General SCHRIEVER. Well, I did say in March that it would require some \$60 million, but the definition of the program to be carried out was not entirely clear at that time.

We submitted a development program for a 156-inch booster and a 260-inch booster in April of this year. It was substantially in line dollarwise with the numbers that I mentioned.

This program was considered to be, and is, a development program rather than an advanced research or a feasibility demonstration program. We were directed to reconsider this program and come in with alternatives more in line with the agreement that had been reached between Mr. Webb and Mr. McNamara to conduct an advanced research technical feasibility demonstration program.

This direction came some time during June. We are in the process of preparing this alternative program, and it is to be submitted to the Department of Defense for consideration by DOD and NASA before the end of August. We are scheduled to have it in my headquarters next week.

I think the question is a matter of program definition. The program that we originally came in with was considered to be, at least to a degree, for a backup to the lunar program. Since the decision had already been made that liquids would be used, we were asked to reconsider and submit an advanced research technical feasibility demonstration program which would not be as costly as the one that we had submitted. That program would have committed us to very large facilities that would have been necessary for a complete development program.

In other words, we were directed to try to do the program at existing facilities and at the same time demonstrate the feasibility of the large solids. In this connection, NASA also changed its plans with respect to the time at which it wants to make a decision with respect to the NOVA or ADVANCED SATURN follow-on. That decision time is some 2 years into the future, 2 years from April to be exact. We feel that we can conduct a feasibility program and demonstrate the potential of large solids so that a decision can be made

at that time whether or not NASA proceeds with a liquid program or a large solid program.

Now this is essentially the background. I did say in March that we would require about \$60 million in fiscal year 1963 for the development program which we envisioned at that time. That program was a relatively large program and was not specifically in keeping with the guidance contained in the Webb-McNamara letter.

Mr. PEACOCK. Sir, actually what happened, the committee asked NASA to present their parallel approach for developing a large solid booster program paralleling the lunar liquid booster approach. We understood the program presented to the committee carried the concurrence of not only the Air Force but also DOD.

Subsequent to receipt by the committee of this particular program outline the \$40 million included on chart No. 1 for the development of the 156-inch and 240-inch has been deleted and that these two projects are not going to be carried forth as indicated.

One thing I would like to ask, sir, is when you presented your program, to the Department of Defense for the development of these large solid propellant motors, was it turned down based on the fact that it was to be a backup program for the NASA lunar endeavor, or was it turned down on the basis that, at this particular time, the state-of-the-art has not advanced to such extent that it was feasible to start on the actual development program for a large size solid fuel motor?

General SCHRIEVER. Well, it has actually never been turned down officially.

Mr. PEACOCK. Held in abeyance?

General SCHRIEVER. Held in abeyance. The reasons were not on technical grounds. The reasons were that the program was not sufficiently responsive to the agreement between Mr. McNamara and Mr. Webb with respect to the nature of the large solid-propellant program. Furthermore, it is considered to be a larger program than is required to achieve the technical feasibility demonstration which would permit NASA in 2 years to make the decision to go either liquid or solid.

In connection with this chart, it is not my understanding that there has ever been agreement in detail between DOD and NASA with respect to the program in terms of details and specific dollar requirements. I think this is correct?

Dr. KAVANAU. That is correct.

Mr. PEACOCK. Did you base the program you presented on a NASA requirement that had been presented to the Air Force?

General SCHRIEVER. It was our interpretation of the NASA requirement as we understood it at the time. We worked with NASA on this, of course, and we certainly did not operate in a vacuum.

I think it is fair to say that people down at the working level sometimes come up with programs that are a little bit bigger than the people at the top want to approve. I think we have all had that experience.

Mr. PEACOCK. The objectives changed and the program had to be reoriented?

General SCHRIEVER. The objectives have been essentially the same since November of last year, but it is not always easy to translate such objectives into a specific program. I think this was the case here.

Mr. PEACOCK. In your opinion, General, has the state-of-the-art for the development of large solid-propellant motors advanced to such extent that you feel the Air Force could actually award a contract for the development of a 156-, 240-, or 260-inch engine and start a development program?

General SCHRIEVER. My personal opinion is that the state-of-the-art has advanced to that extent. The requirement for such an engine, however, has not been firmly established.

Mr. PEACOCK. You mean the requirement against a particular mission?

General SCHRIEVER. Yes. Either the NASA mission or the Air Force mission.

Mr. PEACOCK. In your opinion don't you feel the advancing state-of-the-art in this particular area demonstrates that it can be done, and that missions would be defined subsequent to the time that you actually started this program?

General SCHRIEVER. The program has that very objective, to advance the state-of-the-art and to prove the feasibility beyond any shadow of doubt.

My own personal opinion is that the feasibility exists, but I think that it is fair to say that the kinds of money that will be involved in a NOVA or ADVANCED SATURN really require that we go through this feasibility demonstration. We are not talking about millions but about billions of dollars when we talk about this kind of program.

Mr. PEACOCK. Are there contracts out now which are going to come up with the answer on this feasibility program within the near future?

General SCHRIEVER. There are no contracts out now that can be said to be specifically directed toward the 156- and the 260-inch application. There is, of course, a lot of work going on in the solid-propellant area that has a bearing on them, but the answer to your question is, "No, there is not."

Mr. PEACOCK. What is holding you back from vigorously pursuing this particular program, what is the restraint?

General SCHRIEVER. It is the requirement for definition of the detailed program content, which I said we would come in with. We have presented one program. I told you what the reaction to that program was. We are coming in with an alternative program now which we hope will be more nearly responsive to the agreement at top levels. If it is, I hope it is, we should be able to get a program underway and under the contract in a relatively short period of time.

Mr. PEACOCK. What would this be equivalent to in dollars?

General SCHRIEVER. It is a little hard to say, for me.

Mr. PEACOCK. Just a ball park estimate. Are we still talking 40 to 60 million?

General SCHRIEVER. In this fiscal year, no. I would say it would be considerably less than that.

Mr. PEACOCK. Do you think there is adequate money in the combined Defense and NASA budget to take care of this requirement in fiscal year 1963?

General SCHRIEVER. Counting the carryover from 1962, plus what is in the 1963 budget, there are adequate funds, in my opinion, to do this.

Mr. KING. General Schriever, let me see if I understand what you are saying.

When we met in March the information given to this committee was that the consensus among NASA officials, and I suppose Air Force officials, was that a development of a 120-, 156-, and a 240- to 260-inch diameter motor was indicated as a logical attempt to develop the state of the art in large solid fuel motors. That was the general understanding of this committee.

It was recognized then that although a definite mission, a very specific and definite mission, may not have been contemplated at that time; nevertheless, the pursuit of this program of development was indicated with the idea that missions would be worked out as the R. & D. proceeded.

Are you stating to this subcommittee now that the lack of a specific mission has caused the Air Force to alter its thinking with regard to the value of pursuing this R. & D. program for the 156- and the 240-inch large solid motors?

General SCHRIEVER. No; I am not saying that.

Mr. KING. Would you restate then? I want to be certain we understand.

General SCHRIEVER. The first part of your statement, with respect to our understanding at that particular time, is correct, in that we did present a development program for the 156- and 260-inch motor in April. We called it phase 1.

What I said in March reflected our thinking at that time with respect to the kind of program which we felt should be undertaken. This program was an ambitious program. It would have committed us not just for fiscal year 1963, it would ultimately have committed us to at least a quarter of a billion dollar program, including some very extensive facilities.

The decision at higher levels was that this was too ambitious a program and was more than what was required to meet the technical feasibility demonstration. That was the actual objective of the large solid propellant program defined in November 1961 and reconfirmed again at a later date between Mr. McNamara and Mr. Webb.

I was not in bad faith with the committee, because at that time we were working on a program which was of that magnitude.

On the other hand, I think it is fair to say—and I have been in all kinds of programs—that you can carry on feasibility programs that are very productive but do not risk overcommitment too early.

For example, in 1954, when we started the ICBM program, we had a lot of solid propellant advocates who wanted to go to a solid propellant ICBM immediately. I could not get them out of my hair, so I invited them out to the west coast. They spent a summer out there and came up with a cobbled-up arrangement which nobody in their right mind would buy and we, of course, did not buy.

It did stimulate a lot of thinking, however. We started a feasibility program in which every major solid propellant contractor in this country participated. We identified the areas that were critical to an ICBM capability: mass ratio—that is, the rate of case weight to propellant weight—nozzle problems, vectoring nozzles, specific impulse of the solid propellant, and characteristics of a large diameter.

After all, we never had gotten anything beyond maybe 12 to 20 inches at that time.

We carried out this program for 2 years. It involved study, analysis, and experimentation. It cost us—I don't remember the exact numbers—I think \$5 million the first year and about \$15 million the second year. That feasibility program established the feasibility of building the type of solid propellant motors such as now are in the MINUTEMAN and POLARIS. These two programs actually stem from that feasibility program.

We could have immediately gone right into a much larger program and have decided to develop a 260-inch rocket. We did not do that. It would have been a much more expensive program. We proved to our satisfaction in this feasibility program it could be done and then we moved into the development of these weapon systems that I have mentioned.

I can assure you that I am a very strong advocate of the solid propellant field. We have pushed very hard and the Air Force has pioneered a lot of work in the solid propellant area, but I do not disagree with the DOD position in this matter of taking a hard look at the nature of the program which we should undertake. We do not want to commit ourselves to unnecessarily large facilities and things of that nature before we are sure that these are the motors that we actually are going to build for the next NASA mission.

We do not have a requirement in the Defense Department at the moment for, say, a 260-inch solid motor. I think NASA might very well have. NASA may very well make the decision to go that route rather than the liquid route, but they have said they have 2 years in which to make this decision. I therefore think it is sensible for us to go in the direction that we are going now, limiting the program to feasibility demonstration.

Mr. KING. I, for example, have been a member of the committee almost 4 years now. I remember 3½ years ago, we were talking about the place of solid fuel propellants in our overall space program.

At that time there was a great deal of pressure being exercised to resolve this matter as quickly as possible. Solid fuel propellant advocates were claiming at that time, as they do now, that they could trim off several years from the timetable for the achieving of our overall objectives if we traveled the solid propellant route—at least, in some areas—if not completely, at least solid fuel was to have a role to play.

Three and a half years later, it seems to members of this committee, we are just where we were 3½ years ago; the matter is still unresolved. Now you are mentioning that NASA is talking in terms of another 2 years before the matter must be resolved. It seems curious that they do not find it a matter of urgency to start the development program on the 156- and 260-inch motors, as it was agreed, or understood, last March should be done.

Now your testimony, as I understand it, is that they have since decided that pursuing these feasibility studies on the 156- and 260-inch motors was too ambitious. They are now revising their plans in this regard and have 2 years in which to finally make up their minds; is that correct?

General SCHRIEVER. No. I cannot speak for NASA, but NASA is very interested in the 156 and the 260. They have asked that we carry out a program to demonstrate the technical feasibility of these systems. I have said that they would not make a decision as to the direction that they would go on a NOVA or ADVANCED SATURN, until 2 years from now—at least, that is what they have indicated to DOD—I think this is a matter between DOD and NASA.

I think we will and can be completely responsive to this objective of permitting NASA at that particular time to make the decision as to whether they go solid or go liquid.

It is also true that NASA made the decision last year that they would go liquid on their lunar program. This eliminated the large solid as a backup which was the original intention. We had originally started out with the solid being a backup to the liquid in the lunar program. This role was eliminated in November and changed considerably the nature of the program.

That is not a decision that I made. That was a decision made by NASA.

Mr. PEACOCK. If the decision had not been withdrawn, to provide a solid booster backup for the lunar program, could the Air Force have provided the necessary solid motor that would give NASA this capability?

General SCHRIEVER. I think this is a matter of judgment.

Mr. PEACOCK. Your personal opinion?

General SCHRIEVER. My opinion is "Yes."

Mr. PEACOCK. I would like to get back, if I may, Mr. Chairman, to requirements.

Mr. KING. Let me just ask one question.

Will you state once again what is the present status of the so-called 156- and 240- to 260-inch motor development program? As of this minute where do those two programs stand?

General SCHRIEVER. They are still in what we call a development plan status. We have submitted one proposal, which I have already covered. We have been asked to submit another proposal. This is a development plan, which presents specifically what we want to do and outlines the technical objectives, schedules, the dollars required, and so forth. This is due in my headquarters next week, and we propose to submit it to the DOD immediately. That is the present status.

How soon a decision will be made at the DOD-NASA level with respect to proceeding with this program, I cannot say. I have talked to Dr. Kavanau and I know the NASA wants to proceed with this program, so I think that we would get on with it quite promptly.

Dr. Kavanau might want to comment.

Dr. KAVANAU. That is correct.

I believe Mr. Dixon commented on this yesterday. This process of establishing general requirements, determining what the industry can do, in the sense of what specific jobs the Air Force planners working with the NASA technical people feel are the critical questions, is an iterative process.

This will be coming to us next week, I am sure.

Mr. PEACOCK. You will not wait 2 years to make this decision, will you?

Dr. KAVANAU. I hope not. I think you can expect that this plan, when it is approved both in DOD and NASA in terms of what it will do and what the jobs laid out in the future objectives are, should be forthcoming in the not too distant future.

In 1, 2 months maybe.

Mr. KING. I would like to say, speaking for myself, that I think too much time has elapsed now in resolving this matter. I am harkening back again to 3½ years ago—and this almost sounds like a repeat of what we went through at that time.

As far as we know, the Russians are moving ahead with great alacrity on this same front. If we talk in terms of making up our minds in 2 years, I think we may find the Russians will have increased their tremendous lead in this field.

Dr. KAVANAU. I think General Schriever can outline the kind of progress that has been made in the last 2 years.

There has been significant progress.

Mr. CHENOWETH. Mr. Chairman?

Mr. KING. Yes, Mr. Chenoweth.

Mr. CHENOWETH. I think I should make a brief comment at this stage.

General Schriever, don't think my silence here indicates my acquiescence in all of the attitudes which have been taken by the committee.

I have been a neutral in this situation. I want to say I have full confidence in you. I have always had. I believe you are going to make wise decisions. I sense here a feeling of criticism that maybe you have not moved fast enough in certain fields.

I have no basis whatever personally, as a member of the committee, speaking only for myself to join in that criticism.

I want to make my position clear, Mr. Chairman.

The chairman of this committee, Mr. King, is very able, and in fact is extremely knowledgeable in the solid fuel field.

As I say, I have been a neutral. You have indicated certain pressures have been exerted on you. It is obvious there is an influence here to push forward a little faster with the solid fuels than we have been. I don't know whether anyone has been derelict, negligent, or perhaps maybe dilatory in their approaches.

I said I have full confidence in you, General Schriever. I have been a member of the committee the same length of time as Mr. King. I have never changed my opinion of you. I feel that you are to make very important decisions. I have full confidence you are making them every day to the best interests of this Nation, the defense program, and development of our missile program. That is my personal feeling.

So I wanted to make my position absolutely crystal clear.

General SCHRIEVER. Thank you very much for your confidence.

I think the decision with respect to going ahead with liquids on the part of NASA was their decision, and I think they had good reasons for doing what they did. This changed the degree of urgency associated with large solids in terms of a development program as such.

I think that Mr. King is right, that we could have moved faster. This was not in the hands of the Air Force to do because of these other considerations—and I do not want to be critical of these other considerations. We in the Air Force are very anxious to proceed with a sensible large solid propellant program.

We also want to be completely responsive to NASA. We are working with them every day, and I hope that the program that we come up with will be completely satisfactory to NASA. I am sure that if it is not, they will let us know about it, and we will change it to the point where it is.

I think we all must recognize that moving into the very large solids in a big way is a major decision for the country to take. It will be an extremely expensive program and will involve very large facilities that have to be located in places other than where they are today. These are considerations that have to be decided upon at levels higher than mine.

My command might be more enthusiastic to get ahead with something more, perhaps than the overall situation warrants.

Mr. KING. I agree with what you say, but conducting feasibility studies to the tune of \$20 million apiece for these two programs, is in itself not an unreasonable expenditure. I am sure you would agree that this would give us the foundation from which we could make a rational appraisal as to the feasibility of the entire program.

General SCHRIEVER. I think it is going to take more than feasibility studies; it is going to take experimentation. I cannot yet give you the dollars that will be involved in carrying out a sensible technical feasibility program, but I can assure you that the plan which goes forward from the Air Force will be sensible in my opinion or else I won't send it forward.

This does not mean that what we sent in before was a mistake. It was more in line with a backup program. We were, perhaps, overzealous to get on with a larger program. It was necessary however, to achieve the objectives which were laid down.

Mr. KING. Then, from what you have said and from what Mr. Dixon said yesterday, sometime between now and when Congress reconvenes next January, a very definite, concrete plan will be formulated and agreed upon which will resolve this matter. Is that correct?

General SCHRIEVER. If we do not have a program underway by that time I think that Dr. Kavanau and I had better not appear before this committee. [Laughter.]

Mr. KING. May I say, I agree. [Laughter.]

I just wanted to pin that down for the record, because up to now this has been a little bit indefinite, and perhaps, has been one of the reasons for the frustrations of some of the members of this committee.

I am glad to get this target date.

Mr. Daddario, Mr. Corman, and any other members of the committee, feel free to interject your views at any time.

Mr. Corman?

Mr. CORMAN. Politics being what they are in Utah, he had better not plan to be before the Senate next year. [Laughter.]

Mr. PEACOCK. For the record, Mr. Chairman, in keeping with Mr. Chenoweth's remarks: The Air Force really is not making the policy decision on which road to follow; they are acting in the capacity as a subcontractor to NASA and have really two bosses, NASA and DOD, to satisfy.

The Air Force stands ready, willing, and able to carry out the program according to the directives from either DOD or NASA. Of

course, they are not going to do anything that would not be technically feasible.

Is that correct, General?

General SCHRIEVER. That is correct. I think once we get an approved program, then we are on the way.

Mr. PEACOCK. Then you make the decisions on how you go and what you do?

General SCHRIEVER. Yes.

Mr. CHENOWETH. Mr. Chairman, one further question—

Mr. KING. Yes.

Mr. CHENOWETH. I thought I heard some reference, General, to costs as one of the reasons why some of these decisions have been made. Is it true that you are entering into a new program which would cost not only millions but billions of dollars?

Is that one of the main factors involved in this decision?

General SCHRIEVER. I think one of the main considerations as to the exact nature of the program certainly is cost. You could, by going into a specific type of program, commit yourself to considerably higher costs than in some alternative approach. This was the case in the program we submitted. I know we can do it for less than we have first submitted.

Mr. CHENOWETH. You have not been able to bring yourself to the point where you want to make a decision and take that route for this high cost program referred to?

General SCHRIEVER. Yes.

Mr. CHENOWETH. I don't think you should be criticized for taking that attitude.

I think you should be commended. I think we should watch out for the taxpayers' dollars. I think the country as a whole and Congress would commend you for that attitude, General.

General SCHRIEVER. The Department of Defense has really done this. I am not the least bit critical of this. I think that in view of the overall situation, we needed this real hard look. At the same time I want to make it clear that we want to achieve the objectives that have been laid down. I think that is the important consideration, but there is always more than one way of doing it.

Mr. CHENOWETH. You feel by postponing this decision you are going to save some money, you will do it cheaper than you originally contemplated?

General SCHRIEVER. I think we will do it for less. There is no question but that we can do it for less than we had submitted in our previous planning.

Mr. CHENOWETH. Thank you very much.

Mr. KING. Mr. Daddario?

Mr. DADDARIO. Mr. Chairman, I want to thank you for the opportunity to participate, not being a member of the subcommittee, and I share with you, of course, the concern that we should look into all these fields and the areas of solid fuels is particularly important.

I am pleased to see General Schriever appear before this committee again.

General, you said that you were perhaps overzealous to get on with the larger program at the time the proposal was made to have a back-up to the liquid-fueled boosters.

You also said, in your appearance before this committee earlier last year, that there were tremendous potentials in space, both from a civilian economy, scientific, and a national security standpoint.

Were you overzealous to have a larger program to backup the lunar program, or were you overzealous because you felt that developing the solid-fueled boosters would be in the interest of the national security?

General SCHRIEVER. Well, the former is the case. We were in a climate where our thinking was still conditioned for a backup to the lunar program. I think it is fair to say that the plan was primarily conditioned along the lines of backing up the lunar program.

Certainly we have an interest in the larger solids for national security, over the long term, but not with the high sense of urgency that is attached to certain other programs.

From a national security standpoint, we feel very strongly about the urgency of the TITAN III program. This is, we forget, a 120-inch solid, in itself a very large solid and considerably larger than anything we have today. This program appears—at least in the foreseeable future of the next 6 or 7 years—to satisfy national security requirements.

That does not in any way downgrade our interest in the larger solids. I am as sure as I am sitting here that we are going to need those too at some later stage.

Mr. DADDARIO. Then in this program, you are defining and working out the program details with NASA, which will in the final analysis bring together all the skills both in DOD and in NASA for a step-by-step development program in large solid boosters. In this way we will be developing a program in the interest of our national security?

General SCHRIEVER. Yes. This program that we are talking about now has the primary objective of advancing technology to the point of a certainty with respect to a decision in the time frame that I have mentioned.

I don't know all of NASA's plans, but I know they have plans beyond the lunar landing and return which involve further deep space exploration. They visualize using larger boosters than they now have planned for the lunar landing. It is this lunar program decision that they want to make, I think, and they are projecting a time period of 2 years for deciding whether or not that next large booster will be solid or liquid.

Mr. DADDARIO. Are you confident that the decision-making process as it is working out in this area will bring us to the proper conclusion within a proper period of time?

General SCHRIEVER. I have confidence that we can and will carry out a program which will allow this decision to be made with a high degree of factual data available rather than upon intuition.

Mr. DADDARIO. Are there funds available at the moment within the budget limitations to keep a program moving after the decision is finally formulated?

General SCHRIEVER. Yes, sir; I think that we have adequate funds for that purpose.

Mr. DADDARIO. Thank you, Mr. Chairman.

Mr. KING. Thank you.

Mr. Corman?

Mr. CORMAN. General, what have we learned in the last year and a half that would encourage or discourage us as to the feasibility of these very large boosters, 156-inch and up?

General SCHRIEVER. In the last year we have had nine firings of very large motors—96-inch, 100-inch, and one 120-inch.

Quite a few of these—I can give you this for the record, if you want it—have been completely successful.

Certainly we know more about many technical details associated with a large solid on the basis of these firings.

I would say that these firings, perhaps, have contributed the greatest increase in knowledge leading toward the large solid-propellant booster. There have been other programs carried out in the Air Force. We had about \$14 million in supporting technology during fiscal year 1962. This was spread over a large number of contracts, all aimed at advancing technology.

In addition to the moneys we have been talking about specifically in connection with the 156- and 260-inch motors in this fiscal year, we have about \$10 million associated with supporting technology. There also are the funds that go into the TITAN III development, of course, which is on the order of \$60 million. All of this, of course, advances the state of the art in solid propellant work.

In connection with the MINUTEMAN program, of course, we are always moving ahead in such things as increased specific impulse. We are working to increase range, solve problems of case design, get better mass ratio, and improve cases, and vector control, using gases and liquids. These things are just some of the programs in the technological area that are going on.

We have a very active group out at Edwards Air Force Base where we have our rocket test facilities. I think some of the committee members probably have visited there. If you have not, I certainly would like to invite you to go out there. It is one of the finest facilities in the country on rocket testing and research and development activity, and there is a highly motivated group there.

We have not been sitting back doing nothing. There has been a lot of work going on.

Mr. CORMAN. Has there been anything disclosed that would discourage you as to the feasibility?

General SCHRIEVER. No, sir. Everything that has come along is encouraging.

Mr. CORMAN. As I understand it, there will probably be a NASA use for the very large solid before there will be a military use; is that correct?

General SCHRIEVER. I think that is undoubtedly right.

Mr. CORMAN. Is there any advantage in leaving the responsibility for development with the Air Force, in consideration of that timetable?

General SCHRIEVER. Well, I think there are pros and cons both ways.

The Air Force has tremendous resources, both in manpower and facilities, for managing solid propellant programs. We have been in it for a long time. We have very large programs underway now that are associated with the MINUTEMAN program and with TITAN III, which is just getting underway. We have had a considerable technology program going.

I think that here it is a matter of using the available resources to the best advantage of the Nation. There is no question but that NASA could carry out these programs, but they have got a pretty big bite they are chewing on now too. I think we ought to use our resources to the best advantage.

Mr. CORMAN. The potential loss there would be greater than shifting?

General SCHRIEVER. I can assure you there is no lack of motivation on the part of the Air Force in this area either.

Mr. CORMAN. That is all.

Mr. KING. General Schriever, on that very subject, let me pursue that a minute.

When we discussed this last March with NASA officials, this relationship between NASA and the Air Force, they seemed to feel that the cooperation which they got from the Air Force was excellent, and that the relationship was entirely satisfactory, notwithstanding the fact that on the surface it was a little unusual, because we did point out to them that after all the prime responsibility was theirs and not that of the Air Force to carry out this peaceful, nonmilitary space mission of going to the moon and planetary exploration and so on. This was not and is not directly a military mission; it may have military overtones, but as far as our official policy is concerned anything in outer space was strictly for peaceful purposes. So this was a little bit unusual on the surface, but nevertheless NASA assured us that it was a good working relationship, and I believe you yourself reenforced this feeling with your statement that it was a good working relationship.

As far as we are concerned, the record so stands and it is a good relationship.

But we do hear stories, or rumors, coming to us from time to time that the DOD, which is sort of the umbrella under which you operate, from time to time seems to intervene in, or question, some of these programs on the ground that they are not strictly military programs, which of course they are not.

Now I would just like to ask your comment on this.

Do you find the fact that you are in effect serving two masters—does this create an embarrassing situation to you, does this inhibit in any way the freedom of your activity or create a conflict which may restrict the forward motion of this program, the activation of this program, in which the country is so interested?

General SCHRIEVER. Well, I don't believe so.

I think I can best make my point by simply giving some examples.

Our activity in the solid propellant area is not unique. We have been working in and supporting NASA in many of their programs.

For example, we have the responsibility for the booster in the MERCURY program. Gen. Leigh Davis, who is my commander at Patrick Air Force Base, is responsible for all of the activity having to do with range support of the MERCURY program, for example. We also have the responsibility for the booster in the RANGER program.

In other words, if you took a look at the total composition of the NASA program today, you would find Air Force in it in almost every program that we have. We worked with them for all the years that NASA has been in existence.

We have turned ATLAS, TITAN, and THOR launch facilities over to them. We have turned over rocket test stands at the rocket test center at Edwards Air Force Base, also.

We have had a long association of working closely with NASA in their programs, and we have constantly attempted to improve this working relationship. I believe that in March I indicated that we were in the process of establishing an office working directly with NASA and physically located with NASA here in Washington. My Deputy Commander for Manned Space Flight, General Ritland, who was my Commander of the Space Systems Division in Los Angeles, has moved into Washington. He and his staff are working with NASA right in the same physical location.

I might say that creating this office was worked out between Dr. Seamans, Dr. Holmes, and myself over a period of time, and I think it is merely another demonstration of our efforts to work very closely together. I don't see that there would be any problem in the solid propulsion area.

Going back specifically to the DOD part, it is true that DOD gets into the program during program definition and approval, which is proper. Once a program is approved, DOD does not interfere with our day-to-day working relationships with NASA at all. This process of defining the solid propellant program is what we are going through now.

Mr. KING. Your statement then is that a continuation of this relationship is indicated, that you see no conflict, and the fact that you are undertaking nonmilitary assignments in no way creates a conflict of interest, or embarrassing duality of assignment?

General SCHRIEVER. That is what I am saying. I think that resources in this Nation being as critical as they are, particularly in people, it is highly essential that NASA and the Air Force work closely together.

And there is, of course, another important reason and that is that there is nothing done in the space field that does not have some potential national security use.

These are the reasons why we should be working closely together.

Mr. DADDARIO. Mr. Chairman?

Mr. KING. Yes.

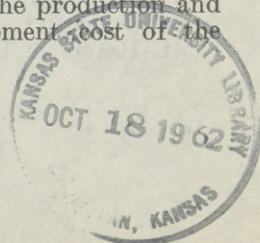
Mr. DADDARIO. Aren't we, General, also following out the intent of the Space Act as written by Congress that there be the most effective use made of all scientific skills, abilities, and facilities wherever located. And that this work is well within the intent and import of the Space Act as written?

General SCHRIEVER. I think so; yes, sir.

Mr. PEACOCK. General, are you responsible for funding in your budget to meet NASA objectives in the case of the development of large solid propellant motors?

General SCHRIEVER. Development of the large solids is a DOD funding responsibility.

Now, if NASA should make the decision to use this large solid booster for their purposes, they would fund for the production and procurement of these boosters, but the development cost of the motors—



Mr. PEACOCK. In other words, NASA places a requirement on the Air Force, then the Air Force programs for and funds for it in their budget, NASA does not budget for it and transfer the funds to you people.

General SCHRIEVER. No. The development costs are funded by the Defense Department.

Dr. KAVANAU. Certainly in the advanced development area, getting to the point where NASA will make the decision to use large solid motors for vehicles, this has been the policy as set down, when this can be done within a reasonable amount of money.

Mr. PEACOCK. Let me take a hypothetical case.

NASA places a requirement on the Air Force to develop a 500-inch engine. The Air Force then would determine how much it costs and place it in their budget.

Would this requirement in the Air Force budget be subject to DOD review?

Could OSD red line the money for this particular requirement, and prevent the Air Force from carrying out the commitment NASA had placed on them?

General SCHRIEVER. I think before NASA would place a requirement for the development of such a booster there would have to be agreement between Mr. Webb and Mr. McNamara. They have to agree on every new booster program. There would have to be agreement at that level before you started out.

Mr. PEACOCK. On the development of a motor.

General SCHRIEVER. Yes.

Mr. PEACOCK. Once the agreement was made, NASA has the privilege of placing the requirements directly on you and you fund for them; is that correct?

General SCHRIEVER. Under the present agreements, DOD has the responsibility for the solid propellant development and the development would be funded by the Defense Department under the present arrangements.

Dr. KAVANAU. I would like to comment—

Mr. PEACOCK. Yes, Dr. Kavanau.

Dr. KAVANAU. I think that the main question you have to face here is: How large is this development program?

Is it a development of approval to go through PERT to build and test flight hardware that will essentially be coupled with a vehicle and flown? This kind of program is very expensive.

Mr. PEACOCK. Let's limit it to the development of a motor.

Dr. KAVANAU. The development of a motor that is to do no job, it is a "rubber" motor.

Mr. PEACOCK. To advance the state of the art.

Dr. KAVANAU. That is the Defense Department's responsibility at this time; yes, sir.

Mr. PEACOCK. NASA would place the requirement on the Air Force and they would fund for it. Then does DOD come into the act again?

Dr. KAVANAU. Yes. We are working to insure that these requirements be established in the kind of a manner which both our organizations can best utilize them.

Mr. PEACOCK. This is the area of great concern to the committee.

When the committee was told \$40 million was budgeted for the development of the 156- and 240-inch motors as shown on the existing charts you have in front of you, the indication was that the Air Force acting in good faith had budgeted to meet a NASA requirement. Subsequently the DOD entered into the act and withheld this money, which prevented the Air Force from carrying out their NASA commitment in this field.

When funds are actually in the Air Force budget what influence does OSD exercise over their expenditure after Mr. Webb and Mr. McNamara have made a decision and a requirement has been placed on the Air Force to do the job? At this stage of the program what restrictions can OSD utilize in preventing the Air Force from getting the money to meet their commitment?

Dr. KAVANAU. The only restriction of Mr. McNamara and Mr. Webb is approval of that program in the light of their agreement.

Mr. PEACOCK. If the program by Mr. Webb and Mr. McNamara is approved there is no restriction on the Air Force, once that money is in their budget. They can run with the ball. They cannot be "re-programmed" out of business, nor can that money be taken away from them by OSD?

Dr. KAVANAU. Let me say the following, that the Defense Department considers its responsibility to support NASA is a very important one, and it is doing this continually, and when it budgets for a program which is approved by Mr. McNamara and Mr. Webb and the program plan and the objectives set forth in this program meet these objectives, that is what the money will go for.

Mr. PEACOCK. Is there a possibility, that OSD could actually withhold the funding and review the program again at a later date, before the funds are actually released to the Air Force?

Dr. KAVANAU. Mr. McNamara could.

Mr. PEACOCK. The Air Force does not have absolute control of the money.

Dr. KAVANAU. I think you have to look at the budget cycle.

There is \$40 million in the budget to carry out large solid work.

These budgets have to be made up some time in the future. As plans are developed and programs essentially spelled out in more detail, the Air Force in working with NASA details these, they come in for approval, both by NASA and the Department of Defense.

Mr. PEACOCK. The reason the committee is so interested in this particular aspect is, normally NASA budgets for their own funds and then they transfer these funds to the agency doing the work, similar to the subcontractor in industry, or to other Government agencies, such as Coast and Geodetic Survey.

In this case NASA saw fit to make an agreement with the Department of Defense whereby the Air Force would do the budgeting and fund the program. It looks like there is a little loophole in the cycle where, even though the Air Force and NASA were in agreement on an approved program by the top people, the OSD still has a string on the funding action which could affect the commitment even though the NASA program is strictly nonmilitary.

This is true, Doctor?

Dr. KAVANAU. I don't think so.

There is a string that attaches at almost every level in almost every organization.

If the program is not being responsive to the guidance as laid down by the heads of the organization, I do not think that that is one that should concern you in detail because I am sure you agree that the program should be in accord with what Mr. Webb and Mr. McNamara desire.

Mr. KING. Let me interject there.

The fact is though, Dr. Kavanau, that the law has placed upon NASA and not upon the Department of Defense or Secretary McNamara the responsibility of carrying forward our nonmilitary space effort, and if NASA has sort of gone into partnerships with the Air Force and DOD, that is fine, and we are all for it, but we must not let that obscure the fact that the basic responsibility is still with NASA. I am a little curious, actually, as to why agreement from Secretary McNamara is first required. Not that I in any way question his judgment. On the contrary, I have been one of his most enthusiastic supporters and I think his decisions on the whole have been brilliant, and I am with him a hundred percent.

But that is not my point.

My point is that as a matter of funding responsibility, the law has placed the responsibility on NASA.

Dr. KAVANAU. I think that is correct.

Mr. KING. They have to make their own decision; is that correct?

Dr. KAVANAU. Yes, sir.

Mr. KING. Would you want to discuss this one point I raised?

Dr. KAVANAU. I think you should ask NASA that question.

Mr. KING. But you agree with my statement that the Congress has placed the responsibility on the shoulders of NASA on this?

Dr. KAVANAU. I think it is evident in the law, sir.

General SCHRIEVER. I would like to make one point: NASA is not self-sufficient unto itself. The military services budget a lot of money that supports the NASA programs.

For example, the Air Force budgets for the operation of the Atlantic Missile Range, which supports NASA. We do not get any money from NASA on this.

The Navy has ships at sea that support the MERCURY shots. NASA does not pay for them.

The fact is that NASA is dependent upon a lot of agencies to carry out its responsibilities. It is never going to budget for all of the funds required and then pass them out to people that do the various supporting tasks. The problem is too complicated.

I think your point with this specific program is that because of the length of the fiscal cycle that is involved, in very rare cases when you go in with a budget requirement, do you have a definitive program to say "Here is specifically what we propose to do." What Dr. Kavanau was talking about is that DOD gets into the act again when it goes through that loop of defining a program to carry on the objectives that have been laid down. I think that is appropriate.

Mr. PEACOCK. We are in agreement with DOD action and responsibility during the programing and definitive cycle, to nail it down.

I understand many people could be involved besides DOD during this phase but once the decision is made, it has to go in somebody's budget—correct?

Dr. KAVANAU. That is right.

Mr. PEACOCK. It is at this particular stage placed in the Air Force budget?

Dr. KAVANAU. Yes.

Mr. PEACOCK. But if the middleman enters at a later date and second guesses this operation then NASA has no chance to recoup, time-wise, because the budget cycle has passed, they cannot go back and get money in their own budget, even if they came back for a supplemental. They lose another year.

The concern of the committee, as Mr. King has indicated, is over a period of the last 3½ years there always seems to be a question for the development of these large motors of where the money is going to come from, or it did not get into the right budget. The committee wanted to nail this down, to make sure that once this budget cycle has been complete, that the funding does not keep changing and the money is made available to the developing agency. We thought it had been accomplished in this program, \$40 million for the 156- and 240-inch motors, even though it is in the Air Force budget it would be used to meet NASA objectives.

Then we find out this money will not be spent for these two development programs. Trying to find out why has been rather difficult.

The requirements still exist, as we see it, for the large solid motors to meet NASA requirements and not DOD requirements, but DOD on NASA orders are delaying the program for more studies on directives, and so forth.

If this program has been changed, as you say it has, it will not be a backup for the lunar program, but this money was put in the budget to meet this NASA objective.

Is this money to be spent to meet future NASA objectives in the field of the development of large solid motors, or will it be reprogrammed against some other DOD requirement?

Dr. KAVANAU. Are you asking me?

Mr. PEACOCK. Yes, sir.

Dr. KAVANAU. I think those moneys will be there until the program is definitized.

If more money is needed to carry out the program more money will have to be obtained some place.

If less money, we won't use it.

General SCHRIEVER. I think it is significant here to refer to Mr. Gilpatric's letter to Mr. Mahon, of the Appropriations Committee, dated the 26th of January 1962. I won't read it all, but I think this part is pertinent:

To date 17.1 million of the 50 million appropriated in fiscal year 1962 has been released. It is anticipated the remaining 32.9 not yet released will be used to demonstrate the feasibility of building and firing large diameter motors when more detailed plans for such vehicles are formulated and approved.

So I think the intent is clear that this money will be used for that purpose.

Mr. PEACOCK. To meet NASA objectives—let me ask this question—do you intend to commit this 1963 money within fiscal year 1963?

Is this the present plan?

We are in this fiscal year now.

Dr. KAVANAU. I don't think we will know until General Schriever has completed his plans.

Mr. PEACOCK. I would like to explore the area of requirements, General.

It is my understanding at the present time that in the large—when I say large I mean 156-inch and above—solid motors development area the requirement is primarily nonmilitary; is that correct?

Right now, and the immediate future?

General SCHRIEVER. Right now, I would say that the probability is that these large solids, specifically 156-inch, will be used first by NASA.

Mr. PEACOCK. Would the development of large solid rocket motors provide the Air Force with a capability of developing a space weapons system with great reliability and quick response whereby the United States could neutralize or destroy a manmade object in space that would be considered a threat to our security, especially beyond the range of the NIKE-ZEUS?

SPADATS gives a capability to detect and track, we understand, uncooperative objects in space, but you have no capability to neutralize or destroy manmade space elements that may be a threat to U.S. security.

Wouldn't developing these large boosters, which would give quick response and reliability give you a capability from a military standpoint to be responsive in this particular area?

General SCHRIEVER. This is one application that certainly would be possible. We have not made a detailed analysis of this in terms of what a system like that would require in terms of its total weight in orbit.

We have an inspection system which is in the research and development category. It is primarily aimed at demonstrating the feasibility of being able to rendezvous with an uncooperative satellite.

That is a research and development effort. I cannot really respond to your question as it pertains to the system which you have in mind.

Mr. PEACOCK. What I was trying to do is look forward to determine if there are any military requirements, even though it may be way out in the blue, beyond the horizon, as far as the military is concerned, which may help stimulate the requirement for this type development of large solid motors. I understand one thing the military does want which the liquids cannot provide is a quick response and great reliability and it appears this is one of the attributes of the solid propellant system.

General SCHRIEVER. That is true, and as we visualize the 156-inch, it would probably be a segmented design.

The Titan III is also a segmented design.

I am as sure as I am sitting here that as we proceed down the road, our payload requirement will increase both in the low and high orbits. It would surprise me if we did not find a requirement for the 156 inch down the line as well as for the TITAN III.

We have identified specific requirements for the TITAN III, such as DYNA-SOAR, which is now the X-20.

Mr. PEACOCK. What are the missions for the TITAN III?

General SCHRIEVER. They are the synchronous communications satellite, the X-20, and advanced work in the satellite inspection area. These are the three missions that we feel the TITAN III gives us the capability to perform.

It is certain in my mind, however, that we are going to develop needs for higher payloads, which will bring the 156-inch into the picture. At the moment we do not have these requirements identified.

Mr. PEACOCK. Isn't it true that the capability usually precedes the requirements, that you have to push the state-of-the-art and develop a capability, demonstrate it and then the requirements follow? So it is not really fair to try and establish a requirement and then design the booster to meet the requirement?

General SCHRIEVER. Advancing technology should not be inhibited by the need for specific requirements. We should push forward. I don't mean to say we should push blindly in all directions. We should have some idea what we will use advanced technology for, because we don't have unlimited resources.

We know that the 156-inch has great potential application, even though we may not have a defined requirement. Therefore the need for getting on with the technology is certainly very apparent and necessary.

Mr. CHENOWETH. I would like to inquire, what is the status of TITAN III? Have we awarded a contract?

General SCHRIEVER. We are in the process now. We have gone through what we call phase 1 definition. We had a source selection and we have designated the winner of each of the major subsystems which are parts of the TITAN III development program. We are in the process of negotiating with these contractors at the present time.

Mr. CHENOWETH. TITAN up to now has been a product of the Martin plant in Denver; is that right?

General SCHRIEVER. TITAN III simply uses the TITAN II, which is a storable propellant ICBM, as the core. It has 120-inch solid propellant motors strapped onto its side. These are segmented and can be used either in four segments or five, depending on the payload requirement.

Mr. CHENOWETH. You use a TITAN II, you say?

General SCHRIEVER. TITAN II is the core for the TITAN III. It is the liquid rocket portion of the TITAN III.

Mr. CHENOWETH. With solid motors strapped on?

General SCHRIEVER. Yes. On each side.

Mr. CHENOWETH. Anything been done with that yet?

General SCHRIEVER. We have been through a very detailed program definition phase. We have had a source selection, and we have selected the contractors. We are in the process of negotiating with these contractors at the present time.

Mr. CHENOWETH. What is your time schedule for TITAN III?

General SCHRIEVER. You mean in getting the contracts definitized?

Mr. CHENOWETH. No, having some demonstration firings?

General SCHRIEVER. In late 1964 or early 1965.

Mr. CHENOWETH. What did you say the mission of TITAN III is?

General SCHRIEVER. We visualize TITAN III sort of as a work-horse booster for military applications. We have identified three particular areas of programs for which we need it: DYNA-SOAR, the synchronous orbit communications satellite, and satellite inspection systems (SAINT). There will be others as we go down the line, I am sure.

Mr. CHENOWETH. How long have you been working on TITAN III?

General SCHRIEVER. Defining TITAN III has been an evolutionary process. For over 2 years we have studied and analyzed the follow-on booster, you might say, for the standard ICBM's which we have been using—ATLAS.

Of course, the THOR, which is an IRBM, is the workhorse. The ATLAS has been the booster we have been using for the larger payloads. The TITAN III is a follow-on to give us increased capability from a payload standpoint both in high and low orbits.

Mr. CHENOWETH. What weight payload do you expect to carry in the TITAN III?

General SCHRIEVER. We can put up 30,000 pounds in a low orbit of about 100 miles.

Mr. CHENOWETH. In a high orbit what can you do?

General SCHRIEVER. About 5,000 pounds.

Mr. CHENOWETH. How does that compare with what you have been doing with TITAN and ATLAS?

General SCHRIEVER. The ATLAS can put—I would have to check—

Mr. CHENOWETH. Just roughly.

General SCHRIEVER (continuing). Can put up about 5,000 pounds in a low orbit. With a second stage, AGENA or CENTAUR, it can put on the order of something less than a thousand pounds into a synchronous, 22,300 mile orbit.

Mr. CHENOWETH. This would be a great advancement over what we have been able to do up to this time.

General SCHRIEVER. Yes, sir.

Mr. CHENOWETH. One other question, General.

I would be interested to know what your general observations are on our progress up to this time in our whole research and development space program we have been discussing this morning.

I am always interested in your comment. I know you are never satisfied in what we are accomplishing, but do you feel we have made substantial progress?

General SCHRIEVER. I think we have made very substantial progress. Of course, I would be out of character if I were completely happy, because—

Mr. CHENOWETH. We know you are not satisfied.

General SCHRIEVER. I think from a national standpoint tremendous progress has been made—more than anyone could have possibly hoped for 4 years ago.

Mr. CHENOWETH. Do you have any idea, where you could base a comparison, of our status with Russia in this field now?

You know that has been sort of a very popular indoor sport here, to compare the two space programs.

Do you have anything that you could tell us?

There has been a lot of speculation about our relative strength and what we have accomplished. I have arrived at the conclusion we are doing pretty well in this field—maybe a little better than some think.

I would be curious to know what your thinking is on it.

General SCHRIEVER. My thinking goes about like this—and I am stating my own personal view: I feel that in the overall space field,

particularly as it pertains to scientific achievement and achievement in such areas as weather satellites, communications, and navigation, there is every reason to believe that we are ahead of the Soviets.

In the large booster area, there they are still ahead of us, based on the payloads they have put into orbit. The one area that concerns me most is bioastronautics and the manned space flight area. There is no question in my mind but that they are ahead of us in that area.

We have had our manned orbital flights, but they have put up spacecraft that are considerably larger than those we have put up and they have put a man up for a longer period.

Their program dating way back has been very closely related to the bioastronautic capability.

I think they are ahead of us in this area.

Mr. CHENOWETH. Do you have any question at all about the authenticity and exactness of some of these Russian orbital flights?

You know there has been some question raised about them.

Are you fully satisfied in your mind that they have done everything they claim they have done?

General SCHRIEVER. In my own mind, I am. Yes, sir.

Mr. CHENOWETH. You are fully satisfied of that?

General SCHRIEVER. Yes, sir.

Mr. CHENOWETH. Do you feel within the foreseeable future—the next few months—we will make appreciable gains in catching up with them and perhaps reduce the gap a little bit?

General SCHRIEVER. I think that in the areas in which I have said we are ahead, there is a very good chance we will stay ahead and even go further ahead.

In the manned flight area or bioastronautic area, I don't think we are going to make appreciable gains. It will be a longer, slower process, in my opinion, to get even with them in this area.

Mr. CHENOWETH. Why do you say that, General?

General SCHRIEVER. First, because they have had this larger boost capability which has permitted them to do things with man in orbit that we have not been able to do, and, secondly, they have a tremendous background in bioastronautic activity dating back to vertical shots in the fifties.

We have a very extensive NASA program going today, of course, with Gemini and Apollo, and so forth, but I don't think there is any room to be complacent that we have caught up with them in all areas or that we are going to overtake them literally overnight.

Mr. CHENOWETH. I appreciate that statement.

Just one other question, General.

Let's look at our situation purely from the military standpoint now.

Where are we so far as your defense program is concerned in this missile field?

General SCHRIEVER. In the missile area?

Mr. CHENOWETH. Yes.

General SCHRIEVER. Well, I think here—

Mr. CHENOWETH. Leave out the manned flight and communications and weather—all that.

Purely from the military.

General SCHRIEVER. I perhaps am somewhat biased, having been so closely associated with missiles, but I think, in view of the fact that

the missile program has been a national effort that has required the combined efforts of the military, science, and industry, we have made fantastic progress. I can put myself back very easily to the days of 1953 and 1954, when we were simply carrying these programs on paper. Where we stand today I think signifies what a democracy can do when it sets its mind to it.

I don't think that the Soviets have missiles such as POLARIS and MINUTEMAN. From a development standpoint, which is what I have responsibility for, I think that we are ahead of the Soviets in several areas of missileery. I think our progress has been outstanding. I certainly feel that it has been more rapid and that we have accomplished more than I had any hopes for, or than of the people who were laying down the objectives back in 1954 could have hoped for.

Mr. CHENOWETH. General, you are too modest, I am sure, to take the credit which is due you for success which you have achieved, but I know those of us on the committee, and others who observe these developments, give you that credit.

I commend you for the tremendous accomplishments in these recent years. I think they have been remarkable.

I am reassured by what you tell us, that you feel that we are ready to take care of any military emergency which might develop?

General SCHRIEVER. I certainly agree that we can take care of any military emergency today; yes, sir.

Mr. CHENOWETH. I want to thank you, General. It is always a great pleasure to have you before either the full committee or the subcommittee.

As I stated before, I have great confidence in you, and I see you continuing the good work you started and I think you will make even greater progress in the months and years ahead.

You have our very best wishes in that effort and we want to thank you.

General SCHRIEVER. Thank you.

Mr. PEACOCK. General, you say you are still negotiating a contract for the 120-inch diameter system, is this correct?

General SCHRIEVER. We have selected a contractor—the United Technology Corp.—and we are in the process of negotiating a contract with UTC now. I cannot give you the status as of this moment.

Mr. PEACOCK. Will this be consummated very quickly, nothing is holding it up?

General SCHRIEVER. They have been given certain moneys to proceed. There is nothing holding it up.

Mr. PEACOCK. This program is not being delayed for any reason is it?

General SCHRIEVER. No.

Mr. PEACOCK. This is the normal procedure and time required to award the contract?

General SCHRIEVER. Yes. They have been given certain moneys so they can proceed, which will then be taken care of in the contractual arrangement.

Mr. PEACOCK. Referring back to a space weapons system and what the large solid motors could contribute to it, you indicated there is no stated requirement at the present time which could be applied to this kind of development program, but you instinctively, through experi-

ence, feel in the near future they will play a major role in the military effort and may be utilized as part of the military weapon systems, is that correct?

General SCHRIEVER. I think so.

Mr. PEACOCK. It is instinctive?

General SCHRIEVER. Yes.

Mr. PEACOCK. Even though you do not have a definite requirement?

General SCHRIEVER. Yes. If we project our requirements out in the future where they become a little bit vague in terms of mission, our payload requirement will certainly increase to the point where this kind of a booster would be necessary to do the job.

Mr. PEACOCK. One other question before we stop.

Have you considered, say, making a "quantum jump," instead of developing 120-inch motor going directly to 156- or 260-inch motors to provide a greater boost capability in a shorter period of time?

What would be the advantage or disadvantage to going directly to the 156-inch motor rather than going through the step of the TITAN III and the 120-inch motor?

General SCHRIEVER. Of course, this goes back to the overall considerations of this group that was set up last summer.

Dr. KAVANAU. Large Launch Vehicle Planning Group (LLVPG).

General SCHRIEVER. They came up with a spectrum of boosters that would be required. I think that they came up with a pretty sound plan. I think that the TITAN III is the appropriate approach to take at this particular time as far as our needs are concerned.

Mr. PEACOCK. Do you consider it a steppingstone?

General SCHRIEVER. I would visualize it so. These plans are expensive. I would certainly visualize TITAN III would be a booster that we would be using for 10 years or more.

Take the THOR, for example. The year before last we said we would not use the THOR any more.

Last year, we said we would not continue to use the THOR, but every year we put in another production order for more THORS. I am sure this sort of thing will happen down the line with other boosters.

Mr. PEACOCK. Is there any question in your mind that the Air Force has the capability to be responsive to NASA's needs in the area of developing these large motors?

General SCHRIEVER. Absolutely none.

Mr. PEACOCK. That is all.

Mr. KING. Is there anything further?

I might say again, General Schriever, and Dr. Kavanau, we appreciate your coming here.

I concur in the fine things that Mr. Chenoweth said.

Your devotion to duty and the brilliance with which you have executed it I think is reassuring to the country.

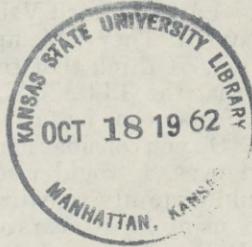
I would like to add the thought that, speaking for myself, I am very interested in the solid fuel propellant development program.

Any time that the Air Force should come and make reasonable proposals with regard to the further development of these programs, I can assure you, for myself, a very, very sympathetic ear, and having sounded out the opinions of the other members of this committee, I

think I can say that you will find generally a great deal of sympathy in this committee for any reasonable proposal.

We agree that money should not be wasted; we agree that the plans should be carefully weighed and evaluated, but within these limitations of reasonableness, I think you will find a very, very sympathetic audience when you come and present these proposals, and we are most anxious to see that this program moves full speed ahead, so that this—I don't want to use the word "controversy"—it is not a controversy—but this area of an uncertainty can be resolved as quickly as possible, so that then we can move ahead with a definite program.

If there is nothing further, this subcommittee will stand adjourned. (Whereupon, at 11:55 a.m., the subcommittee was adjourned, subject to call of the Chair.)



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