MISSILE DEVELOPMENT AND SPACE SCIENCES

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Thursday, February 5, 1959.

The committee met in open session at 11 a.m., in the caucus room, Old House Office Building, Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order, This morning we have as the first witness the Secretary of the Army, Hon. Wilber M. Brucker. I am going to suggest to the Secretary, if he will—he has a prepared statement, a copy of which is in the hands of every member of the committee—that he proceed with his statement without interruption. Then we might have the statement of Brigadier General Barclay without interruption and after that there may be questions. At any rate, we want to handle this as Secretary Brucker wishes it to be handled.

We are happy to have you, Mr. Secretary, and if you will, proceed with your statement as you wish.

Secretary BRUCKER. Mr. Chairman, members of the committee, I do have a brief statement and would like to read it. I think brevity will be better served.

I appreciate the opportunity to introduce the Army appearances before this committee and would like to make a brief comment on the Army's general interests and roles in the national missile and space programs. But first, Mr. Brooks, may I compliment you for your outstanding assistance and contributions to the military services during your tenure in Congress and especially for the exemplary work you did last year as a member of Mr. McCormack's very fine and worthwhile Select Committee on Space and Astronautics. We are very impressed by the way your committee has started out this year. We wish you the maximum of success and assure you that the Army will assist you and your committee in every way possible.

In preparing itself to perform its missions, the Army must explore any and all means which will increase its capabilities. Such a procedure is not merely desirable; it is mandatory, since science and technology today advance with such bewildering speed. This rapid advance in the state of the art, particularly in the past few years, has drastically and abruptly altered our traditional concepts of warfare. Our Nation and the Army cannot rely on historical precedent but must constantly seek to improve our capabilities through this technological advance. Specifically, earth satellites, ballistic missiles, and other manmade vehicles designed to travel through outer space or the upper limits of the earth's atmosphere provide highly promising

means for the Army to improve its ability to fight and accomplish its assigned missions.

The Army's capability in missiles and space has developed throughout its history. From the rocket used in the early 1800's to today's ballistic missile, the U.S. Army has demonstrated a continuous interest and capability in missile propulsion, guidance, production, and employment.

In 1944 the Army placed a contract—this was a $3 million contract—with the Jet Propulsion Laboratory at Pasadena for general research on guided missiles, with emphasis on rocket propulsion and supersonic aerodynamics. Since that date, 1944, under the auspices of the U.S. Army Ordnance Corps, a highly capable and successful military-civilian missile development team has been assembled. Part of the story of this team, such as the recruiting of German rocket scientists, is dramatic and has been well publicized. Less well known, however, is the continuous search into the unknown of space conducted by the Army in civilian laboratories and in Army arsenals over a 14-year period. This search has ranged from the V–1, the modified German V–2's, the Nike, the Corporal, and the Redstone missiles to the well-known, high performance, operational Jupiter.

Through periods of scant public interest in giant rockets, and modest Army budgets, active ballistic missile programs were maintained. It was this carefully developed missile and space capability which permitted the U.S. Army to reestablish the free world's technological confidence by placing Explorer I in orbit on January 31, 1958. This was accomplished 84 days from the date of the order to go ahead. This remarkable success was no accident; it was no miracle. It was the result of many years of painstaking study, research, development, test, and production involving the participation of many thousands of scientific, military, and industrial personnel. The capability which it reflected was not exclusive to a small group or a particular Army installation. The Army capability in space is associated in the public mind most frequently with the U.S. Army Ordnance Corps and the U.S. Army Ballistic Missile Agency. Without detracting from proper recognition which should be accorded to specific organizations and individuals, the U.S. Army capability is spread throughout the entire Army structure. It is a capability which is a composite of the skills, training, and experience of the Army as a whole and cannot be attributed solely to a single agency.

In accordance with your request, today's presentations are addressed to three fields of vital interest to the Army: Satellite and space vehicles; air and space defense weapons; and ballistic missiles with ranges of 200 statute miles and above.

General Dick, the Director of Special Weapons for Research and Development, will present the subjects of satellites and space defense.

General Beach, of the Office of the Deputy Chief of Staff for Military Operations, will discuss air defense and ballistic missiles; and Brigadier General Barclay, the commander of the Army Ballistic Missile Agency, ABMA, will provide information on the established relationships between the Army Ballistic Missile Agency, the Advanced Research Projects Agency, ARPA, and the National Aeronautics and Space Administration, NASA; and, in addition, will discuss the Army's emerging role in the national space program.

May I now introduce Brig. Gen. John A. Barclay, the commander of the Army Ballistic Missile Agency, following which both General Barclay and I will be very glad to answer any questions on which we may be of help.

Thank you very much.

The CHAIRMAN. Thank you, Mr. Secretary.

General Barclay.

STATEMENT OF BRIG. GEN. JOHN A. BARCLAY, COMMANDER, U.S. ARMY BALLISTIC MISSILE AGENCY

General BARCLAY. Mr. Chairman and members of the committee, I am Brig. Gen. John A. Barclay, commander, U.S. Army Ballistic Missile Agency, a subordinate agency of the U.S. Army Ordnance Missile Command located at Huntsville, Ala.

I will now present a brief statement which you have requested concerning the Army's work on projects as assigned by the Advanced Research Projects Agency and the National Aeronautics and Space Administration.

The timely and aggressive conduct of the national program for the civilian and military exploitation of space requires the efficient utilization of a substantial portion of the total national capability in space technology. In the short period since their inception, the National Aeronautics and Space Administration and the Advanced Research Projects Agency have made outstanding and praiseworthy advances in the effective channeling of this national capability toward the space objectives of the United States. In carrying out these objectives, it appears that NASA and ARPA are recognizing fully the often inseparable nature of the efforts of this Nation in meeting military and scientific objectives in both the missile and space fields, and are relying heavily upon the resources and capabilities of the military services.

In compliance with Executive Order 10793, dated December 3, 1958, the Department of Army and the Army Ordnance Missile Command entered into a cooperative agreement with the National Aeronautics and Space Administration. This agreement has placed the vast resources of the Department of Army at the disposal of NASA to accomplish the objectives of the national space program. Also, in the execution of the Department of Defense directive, dated February 7, 1958, the Advanced Research Projects Agency has directed the Department of the Army to accomplish a considerable number of individual projects in support of its military space objectives. I will present a summary of just how effectively the Department of the Army is fulfilling its obligations to NASA and ARPA in meeting their directives to date. No stone has been left unturned in our efforts to carry out the objectives of the national space program efficiently and expeditiously.

Under the terms of the cooperative agreement between NASA and the Army, the following Army capabilities and resources have been made available to NASA. These include:

1. The commanding general, Army Ordnance Missile Command, has been given full authority as the principal agent of the Army to utilize the vast resources of the Army and Army contractors for the accomplishment of assigned NASA projects.

2. It is contemplated that NASA will establish a team of resident personnel at the Army Ordnance Missile Command for technical contact and direction of effort on assigned NASA projects and to provide a continuing exchange of information on all projects assigned by NASA as well as exchange of information on supporting research in the entire missile and space field.

3. Key scientists of the Army have been made available to serve on NASA technical and advisory committees for the development of broad requirements and objectives in space programs and to assist in the determination of specific means by which NASA may accomplish its overall objective.

NASA agrees that the Army has been fully responsive under the terms of the agreement and that the two agencies will continue to work together to increase the effectiveness of the agreement.

These Army capabilities are being exploited by both NASA and ARPA under procedures mutually agreed upon with the Department of the Army and with the specific Army development agencies concerned. The Army's efforts in this area fall into three major categories:

First is the supplying of highly qualified people with specialized knowledge for participation in long- and short-range space program planning. In this connection we have supplied NASA and ARPA with our views on what the national space program should look like in the next 10 years from the vehicular standpoint. This suggested program would make maximum use of the major items of missile hardware under development in this country, regardless of whether an item is being developed under Army, Navy, or Air Force sponsorship.

Second is the accomplishment of assigned projects, including both space mission assignments and advanced technical development of large space vehicles and their components. In this area, the Army is in the process of conducting a challenging array of projects. The Army Ballistic Missile Agency has conducted to date a total of seven space-vehicle firings in support of the national space science program, now the responsibility of the NASA. These activities have resulted in the placing of three satellites in orbit, including the free world's first satellite—Explorer I—and the accomplishment of a space probe experiment which accomplished its major scientific mission. The missions of these vehicles have been directed toward the radiation mapping of extra terrestrial space—an area which is of vital concern to the planners and developers of advanced space projects, particularly those involving manned satellites and space vehicles. The results to date have been rewarding far beyond the original expectations of those who planned the experiments. A totally unexpected radiation phenomenon has been detected and initially investigated. A continuing series of space probe and scientific satellite launchings has been requested of AOMC by NASA and is scheduled for the near future. These missions will be carried out with the Juno II launching vehicle—the combination of the Jupiter missile booster and high-speed upper stages used in the launching of Pioneer III in December 1958.

One of the most vital and yet most critical phases of the national space program is the NASA-manned satellite project, designated Project Mercury. It is a vital project in that it represents the

initial fulfillment of the major overriding objective of the national space program—that of enabling man to explore and exploit the universe around him. It is the most critical space project to date in that it deals with human life. In recognition of the fundamental requirements for safety and reliability in such an undertaking, NASA has established a rigorous and intensive testing program designed to insure the anticipation and elimination of every possible hazard to human life prior to the placing of a man in orbit. The manned capsule for use in the final orbital project will first be subjected to a number of surface-to-surface ballistic missile flights. For the initiation of this test program, NASA has chosen the Army's Redstone missile. The Redstone is the safest and most reliable ballistic missile currently available. Fifty of these missiles have been fired since the inception of the Redstone program and in only one case, early in the program, would there have been any doubt as to the survival of a human passenger. Even in that case it is probable that appropriate built-in safety devices could have prevented a casualty.

NASA has requested AOMC to provide and fire eight Redstone missiles equipped with the NASA-manned space capsule, beginning in the near future. In addition, AOMC wil provide two Jupiter missiles with which the NASA capsule will be tested under the more severe environment conditions encountered along an IRBM trajectory.

Under the Advanced Research Projects Agency, the Army is carrying out a number of vehicular and payload development projects which are directed toward the immediate military application of space technology. The U.S. Army Signal Research and Development Laboratories are charged with the development of a meteorological satellite which will represent the initial step toward the provision to military commanders of weather forecasts of improved accuracy and timeliness which are so important to the success of military operations. Eventually, this effort may lead to a breakthrough which will make possible the active control of weather over a battle area.

The Signal Laboratories are also engaged in the design and development of satellites for application to rapid and reliable worldwide military communications. The initial orbital experiment in this area was conducted under Project Score in December 1958. The ultimate objective in the communications area is a network of communications relay satellites placed in orbits about the earth's Equator at an altitude of approximately 22,000 miles. At this altitude, each satellite will appear stationary relative to a point on the Equator and will thus make possible the almost instantaneous transmission of messages between any two points on earth.

Perhaps the most impressive single project currently assigned to the Army by ARPA is the development of the Juno V booster of 1½ million pounds thrust, now underway at the Army Ballistic Missile Agency. This vehicle, based on a cluster of improved Jupiter engines, will represent a truly significant step toward the early attainment of parity with the Soviet Union in weight-in-space capability. The Juno V booster will find applications to a large number of civilian as well as military missions of the next decade. This large booster will probably be of great importance in the achievement of the ultimate objectives outlined above with respect to both meteorological and communications satellite systems.

The third category of Army effort is the conduct of technical investigations, applied research, and feasibility studies as desired by NASA and ARPA, including mission selection and systems analyses. In this regard, under the direction of the Army Ordnance Missile Command, the Army Rocket and Guided Missile Agency is conducting and supervising research projects and feasibility studies for ARPA to advance the state of the art in solid propellent technology and to investigate new methods and components applicable to the problem of detecting, tracking, and destroying hostile ballistic missiles. In a closely related area, ARGMA and ABMA have already completed and submitted to ARPA preliminary studies in the area of defense against hostile satellites and space vehicles. The Army Ballistic Missile Agency, in cooperation with the Jet Propulsion Laboratory—now a NASA agency—is carrying out a study to determine an optimum deep-space research program for NASA. ABMA is also conducting for ARPA a systems study of an optimum multirange space vehicle based on the Juno V 1½-million-pound thrust booster. This study will consider various alternatives to upper stages for the Juno V which will be capable of conducting low-orbit, high-orbit, and space probe missions which require such a high-performance booster.

The Army developed its broad capabilities, which are now being used in space projects, as an inevitable result of its progressive work and outstanding success in the field of military missiles. The Army is gratified that as a result of this developed capability it can lend substantial support and assistance to the vital national space program. We believe that not only will this participation serve to further the accomplishment of the Nation's objectives, but also contribute to improved techniques and systems of direct benefit to the Army. The close relationship between missile and space technology is such that improved Army missiles and missile components will result from our space efforts. The Army's capabilities for satisfying its requirements and carrying out its responsibilities in the areas of worldwide communications, worldwide mapping and meteorology will be greatly improved through the experience gained and the components developed in the space program.

Of major importance also is the contribution which our efforts under Project Mercury will make toward the evolution of transport missiles for the deployment of Army troop units and combat teams and the logistic support of Army battle area operations.

I have appreciated this opportunity of appearing before the committee and shall be happy to answer any questions you may have.

The CHAIRMAN. Thank you, General, for a very fine statement.

Secretary BRUCKER. May I supplement this with just one statement.

The CHAIRMAN. Yes.

Secretary BRUCKER. It is implicit in the statements which we have given you this morning, but I think maybe we might have been a little clearer in stating two things here.

On December 3, 1958, Mr. Chairman and members, we entered into cooperative agreements with the National Aeronautics and Space Administration. One agreement provided for turning over the Jet Propulsion Laboratory at Pasadena, Calif., to the NASA which I mentioned in my opening statement and to which General Barclay

alluded. That was effective forthwith, and since December 3, JPL has been under NASA control, the arrangement being that the Army and NASA under the administration of the latter will cooperate to see that the cooperative effort is developed fully.

At the same time as a counterpart, or contemporaneous with it, was an agreement whereby the Army retained the Army Ballistic Missile Agency but provided for a cooperative agreement again with NASA whereby it should have all of the benefits of using the Army Ballistic Missile Agency, its contractors, the Army's contractors, industrialists, our university researchers, our scientists, and those who have worked with the Army and all of our support agencies, to include our technical services such as the Signal Corps, and all of the rest. That agreement is likewise in full bloom at the present time.

Now the second bit of information that we should have supplied, I think, is this: When General Barclay and I spoke about the Redstone and the Jupiter, we take it for granted, of course, that the committee knows the range of those two. The Redstone missile is the one capable of 200 statute miles. It was referred to here by General Barclay as having such reliability that only in 1 of the 50 firings we made was there a question as to whether a man could have successfully been placed in space. I am referring to the 200-statute-mile Redstone. That was the first one developed by the Army Missile Agency at Redstone; and the other was the Jupiter.

You notice he made some distinction about the fact that the Jupiter had been tested on missile firings and likewise would be tested as to the man in space or using of a man in connection with certain Jupiter firings. The Jupiter is a 1,500-mile intermediate range ballistic missile. Those are the two things that I wanted to have said. I would like to say something that I did not at the beginning. I should have introduced at the very beginning the Vice Chief of Staff, Gen. Lyman Lemnitzer who is here at my side. I trust you will all forgive me.

The CHAIRMAN. General, do you wish to make a statement?

General LEMNITZER. No, Mr. Chairman, I do not have a statement.

The CHAIRMAN. Mr. McCormack has to leave early because of official duties on the floor, so I am going to recognize him for any questions at this time.

Mr. MCCORMACK. I only have one or two questions. Because we get more information in executive session than we can in public session. I realize that, and you gentlemen are under restraint. We might ask questions in good faith that you know could be better answered in executive session, I look more to the executive session for real information, because there are times when you cannot make public certain information in the interest of our country and nobody would want that.

It is contemplated that NASA will establish a team of resident personnel at the Army Ordnance Missile Command for technical contact, and so forth. Has that been done yet?

Secretary BRUCKER. I would like to have you answer that, General Barclay.

General BARCLAY. Not as yet, Mr. McCormack. This, of course, is a reciprocal arrangement. The Army Ballistic Missile Agency and the Army Missile Command currently have two engineers resident with the NASA organization at Langley Field. Those personnel reported there the middle of January. NASA personnel are planned

to come in residence at the Army Ballistic Missile Agency and the Missile Command at Redstone but they have not yet joined our staff. We have in residence with us a group from the Jet Propulsion Laboratory who worked in the coordination of our projects prior to the time the Jet Propulsion Laboratory was transferred to the administrative control of NASA. These personnel of the Jet Propulsion Laboratory are remaining in residence with us at the Missile Command.

Mr. McCormack. The cooperative agreement was made when?

Secretary Brucker. Signed December 3, 1958, sir. It was made prior to that time, of course, during the month of November.

Mr. McCormack. We hear a lot about the flight to the Moon and to Venus and Mars, which is very interesting and very important. I recognize that emphasis must be put on it, but from a military standpoint is there any military significance in the immediate or foreseeable future, from say a flight to the moon or around the moon?

General Barclay. Yes, Mr. Congressman, I feel that there is. We are unable to appreciate the military potential of exploitation of space until we know the possibilities. We must do this from the scientific point of view and once we have learned what we can do in space and learned how we may be able to exist in space, we can then better appreciate the military potential of it.

Mr. McCormack. I noticed your statement that the Army is carrying out a number of vehicular and payload development projects which are directed toward the immediate military application of space technology. I assume from that that you have definitely in mind, that while we have the overall program in the years ahead, that it is vitally important in the world of today, from a military angle, that we do not slip up on anything.

General Barclay. Yes, sir, I feel very strongly that that is the case, that we must be abreast of the potential of travel in space and able to command space and utilize it as it offers. Until we have determined scientifically the many things which are unknown at the present time, we cannot fully realize its potential. There is much research to be done. We do not know how materials will react under the vacuum of space over long periods of time. We do not know how lubricants on bearings will stand up under the radiation which we know exists in space and how our systems may continue to operate in space under long periods of time when they may not be accessible to maintenance or repair. There are many other areas such as the effect of meteorites upon satellites and space vehicles which we must learn about. There is a great deal of research that must go forward, and step by step, we will gradually build our capability to utilize space to meet our needs.

Mr. McCormack. Well, I can understand that, but in my mind there is the immediate problem of confronting not only our country but the future world—of not always following but being ahead of any potential enemy in connection with military developments in the world of today. I assume from the language you use that you are speaking of space in general, but it is still language which conveys to the objective mind that the Army has got in mind the military possibilities.

General Barclay. Yes, sir, we have. These programs, however, must be rather long-range programs because of the amount of research

work that must be done and the development work of missiles and missile systems. In order to be ahead we must establish forward-looking goals that we will be achieving in the 1965–70 time span. I think it is only by this means that we can assure not only being abreast of other nations in the world but being ahead of them.

Mr. McCormack. Well, how do ARPA and the Army get along, and NASA? I will not ask about the Air Force, they can speak for themselves. How has your relationship been?

General Barclay. Our relationship has been a very active one, a very close one, and a very congenial one. We have found that ARPA has the ability to face up to problems, to make rapid decisions, and to take action to implement programs rapidly. They have initiated the large booster project which is the first priority requirement for the United States to advance in space; that is, to develop power systems capable of launching into orbit the large payloads that will be needed. That is being undertaken using the Jupiter engine in a clustered configuration which will give us a total thrust of a million and a half pounds.

Mr. McCormack. When?

General Barclay. The first test of that will be accomplished within the near future. I would prefer to discuss the details in executive session.

Mr. McCormack. Fine. Thank you. That is all.

The Chairman. I want to ask you this, General, if I may: You refer to the fact that 50 of these missiles, that is the Redstone missile which has a range of 200 miles have been fired and that in only one case there has been any doubt as to the survival of a human passenger.

Now in reference to that, do you mean that the conditions within the missile were such that you know a human passenger would have survived or do you mean that the missile performed according to hopes and expectations in its trajectory and its career until it returned to the earth?

General Barclay. The missile flight was such that if it had contained a human as a passenger, he would have survived the flight. There was one flight, the third Redstone missile, which rose only a short distance off the pad, the motor stopped, and the missile fell back on the pad and burned.

The Chairman. Well, that is not quite what I had in mind. You do not mean that you have conquered all conditions of survival for an individual had he used that particular missile, do you?

General Barclay. No, sir, I do not.

The Chairman. The speed of take-off and reentry and all of those things.

General Barclay. The missile flight was satisfactory so that if we had had a capsule available for a human being with the safety devices and escape devices which are now planned, the man would have reentered successfully or would have been able to eject himself and return safely to the earth.

The Chairman. Is there any particular advantage, in a military aspect, to accomplishing that? Suppose we put a man in a 200-mile missile. Is there any particular military advantage in learning to do that?

General BARCLAY. Yes, sir, there is. In the first place in connection with the development of an ability to place men in space and recover them, it is essential that we develop our systems and check them out at short ranges. We must crawl before we walk. In the future when we have developed these techniques it appears quite practical that we may deploy both high-priority cargo and personnel to critical battle areas which are not accessible by any other means. The accuracy of placing personnel into an area with a missile will be far greater than that by aircraft.

The CHAIRMAN. In other words, transportation.

General BARCLAY. That is correct.

The CHAIRMAN. What about this Juno II rocket that you are referring to in your statement?

General BARCLAY. The Juno II is a successor to the Jupiter–C which has been used to place the Army's Explorers in orbit. The Juno II is essentially the same system incorporating in its first stage a Jupiter intermediate range ballistic missile with a slightly elongated fuel tank and containing as the top three stages the jet propulsion laboratory configuration for placing a satellite vehicle in orbit.

The CHAIRMAN. That name is obtained from mythology?

General BARCLAY. That is correct, yes.

The CHAIRMAN. I want to ask this, Mr. Secretary, and from all of you: In reference to the project that you have, the missile project for the Army, do you have an adequate amount of money to carry on that project? Is it moving along satisfactorily now?

Secretary BRUCKER. Are you referring particularly to the Redstone and Jupiter project, sir, and also to the Juno and these other projects?

The CHAIRMAN. All of the missile projects that the Army is maintaining at this time. What I am trying to learn is: Is there any effort to cut off the Army in the development of its program? The Army program has been a very satisfactory program.

Secretary BRUCKER. Well, we are operating on a modest budget and we have funds for the continuance of the Redstone for the foreseeable future. The 1959 funds that we have give us the chance to operate that and the means to complete it during the fiscal year 1959, and also the calendar year 1960. The 1960 budget, however, does not carry any money for the Redstone missile.

The CHAIRMAN. Do you interpret that to mean they are trying to choke off the Redstone plant?

Secretary BRUCKER. Well, I interpret that as meaning that the Pershing, which is a solid propellant missile of slightly greater range, will replace the 200-mile Redstone. Since the Pershing is a solid propellant missile it will be more effective in the field with troops.

The CHAIRMAN. Well, that would not be an effort to choke off your operations, but it would be a continuation of the operations along another line; is that not correct?

Secretary BRUCKER. Yes, it would be a continuation at a greater range. There is a time gap in there between the time when the production of the Redstone would be concluded and the time when the Pershing will be operational.

Now as to the Jupiter, we are producing it for the Air Force under the arrangement and order of the Department of Defense. We are producing sufficient for three full squadrons. That work likewise

will continue during calendar 1959 and most of 1960. We have no further orders on it beyond that, and we are subject to whatever the Air Force and/or the Department of Defense may order in that regard.

The CHAIRMAN. Does that fill the requirements for the Jupiter?

Secretary BRUCKER. It gives us enough Jupiters in the meantime so that we can do experimental work during this calendar year and most of 1960.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. We are glad to have you here, Mr. Secretary, and I, personally, want to thank you for your complete cooperation and also General Lemnitzer for his cooperation.

The question of going into outer space is, of course, with what concept do we go into it. Are we going into outer space with the theory of freedom of the seas and to maintain an open and clear outer space so that nobody can control it, or are we going to take Britain's theory of the dominion of the seas? Is our purpose to get control, or power to control, and prevent any other nation or group of nations from having the similar control? What is our purpose militarily?

Secretary BRUCKER. From a military standpoint while I do not, of course, speak for the Secretary of Defense, the philosophy is this, I think: We are going into space to do all of the exploring that we can to find out every possible and conceivable scientific advantage and to get not only the knowledge and the experience and the know-how, but the ability to put tangible physical satellites and things of that nature, in orbit. These satellites may be stationary in the sense that they hover over one part of the world—or they may be moving constantly around.

Mr. FULTON. That brings me to my next question, the jurisdiction of the Army in space. What is it? You have, of course, other surface-to-surface missiles. You would have surface-to-water and surface-to-air, but you would not have air-to-air and you would not have air-to-water, and you would not have water-to-water in the Army.

Secretary BRUCKER. That is right.

Mr. FULTON. Now I understood from your previous presentation that you felt that the Army should be in the orbiting vehicle business. Now would you have the Army have that jurisdiction or would you just have surface-to-air and surface-to-surface and surface-to-water?

Secretary BRUCKER. Mr. Fulton, I do not believe that at this time there is any clear demarcation or definition of where any peaceful or military use starts or leaves off, or where any defense interest in any one of the services or ARPA begins or leaves off, and maybe it is better that there is not, right at the moment. Because, as we move into this field, to have rigidity and inflexibility at this time might not be a good thing for the whole effort. It might be best to have a little obfuscation or blurring of the line between the two.

Mr. FULTON. There is plenty of obfuscation.

Secretary BRUCKER. Maybe that word is a good one. But I think it is better at this time that these lines are not too clearly drawn by inclusion and exclusion.

Mr. FULTON. So we really have some competition on going into space among the various services, militarily as well as in peacetime use.

Secretary BRUCKER. I would agree to some competition: Providing it is monitored and supervised and not just free competition with a

cutthroat idea, without regard to the national interest. This supervision of the three military departments is provided by ARPA, through whom or through which agency we must submit everything and have it approved before anything can go. The same applies to NASA. Nothing can happen without NASA approving it on the other side, and I think those are good controls and supervisions at this time.

Mr. McCormack. Would the gentleman yield there?

Mr. Fulton. I would be glad to yield.

Mr. McCormack. Who would you suggest to be the monitor?

Secretary Brucker. The monitor?

Mr. McCormack. Yes.

Secretary Brucker. Well, I think ARPA, the Advanced Research Projects Agency with the Secretary of Defense in overall command is the proper authority on our part. We must not go ahead without the monitorship of that agency of the Department of Defense. Both ARPA and NASA are subject to the National Space Council, of course, and I think that is a proper arrangement.

The Chairman. Mr. Secretary, in reference to NASA, does the Army Ballistic Missile Agency act as a contractor? What is the relation with NASA?

Secretary Brucker. That is a good question, Mr. Brooks. I am very glad you asked that. With your indulgence I will say this: It is not a contract relationship in the ordinary sense of the word. There is what is called a cooperative agreement that was drafted between the two agencies of Government and signed by both, approved by the Council and of course by the President. It is an agreement whereby instead of having some standoff relationship at arm's length, it is a very intimate relationship where projects have the whole and compelte attention and the opportunity to benefit by the services of every part of the Army organization.

In other words, NASA has not only what they would get by ordinary contract with a private contractor, but they get all of that which the Army has with respect to its university research, its arsenal research, its in-house development capability, its technical services, such mundane things as supplies and equipment and all the rest that is available to the Army.

In other words, it gets the whole backing and support of the Army instead of just an arm's length contract arrangement. So it is a cooperative agreement in every sense of the word and we hope that it will show to all of the agencies of Government what you can do when you get together and really cooperate to make a thing go because it must go.

The Chairman. Well, is it reciprocal? Do you get the same thing from NASA that you give to NASA?

Secretary Brucker. Yes, it is reciprocal in that NASA gives us consideration with respect to projects. That is the quid pro quo that we get. In other words, we are anxious to do their work because it helps advance our military missile technology. So we display to them our wares, the support that we can give them, and they in turn say to us you are qualified to get this project, whatever it happens to be, a lunar probe, or something else, and we take that on, and we are interested in that as our quid pro quo.

So there is a cooperative reason on both sides to cooperate.

Mr. McCormack. What about going a step further beyond cooperative and making it coordinating?

Secretary Brucker. I think maybe that is the word.

Mr. McCormack. I thought you meant that.

Secretary Brucker. I do. I am glad you added that, Mr. McCormack; I want to add another word on the exchange of information. There is a day-by-day, week-by-week exchange of detailed technical information, because one hand washes the other in this business. What we learn about missiles redounds to their benefit and development in the field of science for space generally. What they get in space generally redounds to our advantage in missiles because the two efforts are so close together, like the interlacing of fingers. They work together to help all of us. That is why we think this arrangement ought to work out well for the Army as well as for NASA in the long run.

Mr. McCormack. We must realize that many of the results of the military work and experiments and activities will inure to mankind, and have frequently in the past.

Secretary Brucker. That is correct.

Mr. McCormack. It is a question of understanding men working together who have in mind the interest of our country.

Secretary Brucker. It is whether the men will make it work that counts.

Mr. McCormack. That is also necessary between the executive and the legislative, and vice versa.

Secretary Brucker. Yes, indeed.

The Chairman. Mr. Fulton.

Mr. Fulton. You have spoken of the reliability of the Redstone and said that it is high. For example, Rocketdyne makes the motors and engines for the Redstone, the Thor, the Jupiter, and the Atlas.

Now the Air Force recently has announced that the Thor is up to 50 percent reliability and they expect to have that up to 80 percent by the end of the year. I believe Rocketdyne says they are going to have it above 90 percent if they can. The question is: On the Jupiter, can you give us the present state of reliability of the Jupiter and this same progress that the Air Force has already announced?

Secretary Brucker. I just wonder here about——

Mr. Fulton. I want you to be as open as the Air Force.

Secretary Brucker. We don't want to indulge in any self-interest here, but I just wonder about the classification, because of the nature of this work. I think inasmuch as the Air Force has made a statement on the subject, that we are certainly entitled to make a statement.

Mr. Fulton. It is in print.

Secretary Brucker. General Barclay.

General Barclay. Mr. Congressman, I mentioned earlier that the Redstone has had 50 flights, only one of which we considered a complete failure, in that the objectives were not achieved.

Bear in mind that the Jupiter, being a successor to the Redstone, has inherited many common components and principles of design which went into the Redstone and has, therefore, a heritage of reliability.

To be more specific, the last six Jupiter missiles which have been fired were completely successful in five cases and went the full range. The sixth one, which failed after some 40 seconds of flight, failed due to the failure of a component which was put on it for instrumentation purposes and which was not a basic component of the stockpile missile.

In addition to these six flights of the Jupiter, we fired the lunar probe in December, which had the basic propulsion unit of the Jupiter, and was fully successful through the operation of the first stage.

That is our record since the difficulties with the motor were ironed out. Those difficulties, of course, were common to the motors of both our IRBM systems and our ICBM system.

Mr. FULTON. So that on the manufactured missile, as well as on the fuel, you have had seven successful flights?

General BARCLAY. Of the last seven, six were successful.

Mr. FULTON. One was a component not necessary for the operation of the missile?

General BARCLAY. That is correct. That failure was not attributed to a missile component but to instrumentation.

Mr. FULTON. So let me give you the hundred percent record, which I am trying to do.

Secretary BRUCKER. Just to answer that question a little more fully, General Barclay will indicate that we have had a lot more than six or seven flights of Jupiter. I think he ought to tell about that.

General BARCLAY. Yes, sir; I referred to the last six flights, which are those that have taken place since the motor trouble was corrected.

Mr. FULTON. I realized that.

General BARCLAY. Our first two flights we considered partially successful only because they did not go the full motor-burning time. In the first case we lost the missile due to a heating condition that existed in the tail. In the case of the second missile, we lost that due to a sloshing of the missile fuel. The third Jupiter fired was fully successful and went the full range.

The next two missiles were also successful. Then we had two failures due to motor difficulties, which were cleared up, and subsequently the seven flights which I referred to.

Secretary BRUCKER. I wanted you to have the full statement there.

Mr. FULTON. I want to say this, Mr. Chairman: As I am the only Republican here, possibly as an eager beaver, I am going to make up for the horses against the rabbit on this side.

Mr. ANFUSO. Jim, I think you would want to take that off the record, to show the lack of interest on the part of the Republicans.

Mr. FULTON. I said I made up for that.

Mr. ANFUSO. I think you can. You are very capable.

The CHAIRMAN. We have a rollcall, and the rollcall will indicate those present.

Mr. FULTON. Under subsection (f), labeled "Outer space and the control thereof," of the resolution passed setting up this committee, this committee was given a peculiar jurisdiction. I want to call your attention to it specifically, because (f) says that we have the jurisdiction of outer space, including the exploration and control thereof. So whether you are civilian or military, when you come into outer space, as such, as distinguished from the ionosphere, that jurisdiction is under this committee.

Now, the question comes up. If somebody lands on the moon, because we will have jurisdiction of the moon, will the Army be operating on the moon as such? Is that Army territory? It is ground? And do you then therefore—suppose there is an occupation of the moon militarily, should we therefore have the Army in charge of the moon?

Secretary BRUCKER. Mr. Fulton, I haven't given careful attention to that matter of jurisdiction of the moon or of the flight, and I would want to give it a second thought before I answered it here.

Mr. FULTON. The proposal on the man to the moon is that there would be three people there. I imagine there would be a Navy man, an Air Force man, and an Army man. But if we don't get there in time, we may have to have a marine to make a landing—the Russians may be there first.

The CHAIRMAN. Now, Mr. Miller has a question.

I want to give everybody an opportunity for a brief question here before we are called on the floor.

Mr. MILLER. Mr. Secretary, is the Army's work in space interfering with its work in missiles or, vice versa, is its work in missiles interfering with its work in space?

Secretary BRUCKER. On the contrary, it is augmenting, supplementing, and assisting our work in connection with missiles, so that the Army feels that one hand is really washing the other, and that we are getting benefit out of it.

Mr. MILLER. Is the Army satisfied——

Did you have something further?

General BARCLAY. I mentioned in my statement, Mr. Congressman, that we get mutual benefit in working in our missile program and our programs in space. What we develop for NASA and ARPA is applicable to our military missile systems, and the converse is true.

Mr. MILLER. Mr. Secretary, is the Army satisfied with its current arrangements between your ballistic missile center and NASA?

Secretary BRUCKER. Yes, we are, Mr. Miller, and we are ready to go forward in good faith and to carry out not only the letter but the spirit of the arrangement. We are doing it.

Mr. MILLER. Mr. Fulton raised one question as to outer space, which concerned the Army in outer space.

General Barclay has discussed the desirability of having this missile or satellite fixed with relation to some place on earth, because it would be a means of communication.

The Army is always concerned with communication, is it not?

Secretary BRUCKER. It is.

Mr. MILLER. And the work that would be done in the field of weather that could come out of this thing is of utmost importance to the Army?

Secretary BRUCKER. Very important.

Mr. MILLER. So that you do have a very material interest in outer space or inner space or wherever we can best develop these two things. Isn't that true?

Secretary BRUCKER. We feel we have a very critical and very important interest in it.

Mr. MILLER. I would like to discuss the limitations put on you, but I don't think perhaps this is the place. But as a last question, somebody has referred to Juno being taken from mythology, and I

am not too familiar with mythology. And then just coming on this committee, the jargon of outer space kind of gets me down a bit.

But we heard a lot the other day about aerospace, a new word, "aerospace." Are you familiar with the word "aerospace"?

Secretary BRUCKER. I know about the word, but I am not familiar with the claims made for it.

Mr. MILLER. Have you any comment to make on aerospace and who controls aerospace?

The CHAIRMAN. The Secretary is probably more familiar with "armospace."

Secretary BRUCKER. That is right.

Mr. MILLER. I wanted to say to General Barclay, as an old artilleryman, I am certain that you realize that during World War I we were taught one could disregard the 2 percents. So I think in this case you had 50 firings and only 2 percent went wrong. That is as near perfect as you can get.

General BARCLAY. I was going to add, we have designed the Redstone missile to have artillery accuracy.

Mr. ANFUSO. Mr. Chairman.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Mr. Secretary, I want the record to show that I think that you are a great Secretary of the Army, even though you are not of my party. I think you have done an excellent job.

Secretary BRUCKER. Thank you very much.

Mr. ANFUSO. I want that in the record.

Secretary BRUCKER. Thank you very much.

Mr. ANFUSO. Mr. Secretary, Mr. McCormack asked a question of whether there was any great priority to shoot for the moon, and I think that that question was very carefully and well answered.

Now, would you state that there is any priority to shoot for the exploration of Venus and Mars at this time or can you place other priorities in advance of that?

Secretary BRUCKER. I have been conferring with General Lemnitzer here because that is really a concern of NASA, and I think under the circumstances we should defer to them on that, because they make the decision and while we present, they dispose of it.

Mr. ANFUSO. Thank you.

Mr. Secretary, you have spoken about having a modest budget, which has been sufficient to carry out the projects that you have already mentioned.

Now, in carrying out these projects, will that enable us to catch up with the Russians or pass them, or must we do something more?

Secretary BRUCKER. Do you mean in the field of these experiments that we are making?

Mr. ANFUSO. Yes.

Secretary BRUCKER. Well, Mr. Congressman, I think you would have to take all of the effort together that the military is making in order to get an answer on this.

As far as we are concerned, we have sufficient projects—as far as we can press on this at the present time—and NASA and ARPA have indicated to us that they will support other projects that they are going to turn over to us and the Army.

I can't speak, of course, on the overall, because I don't know what the arrangement would be with the Air Force and the Navy, and what the sum-total would be. But as far as we are concerned, we have in promise or in being now sufficient projects to keep us moving along in this field.

I would like General Barclay, who is right on the floor here, to supplement that, if he would like.

General BARCLAY. Yes.

To catch up is, of course, dependent upon two things: how fast the other fellow is going and how fast we are willing to go.

Certainly we have set goals and we have initiated programs which will provide us a capability, and that capability will come primarily through the development of large power systems, large engines and thrust units which will permit us to engage in a weight-lifting contest with other nations, if you want to express it that way.

Mr. ANFUSO. Well, General, are you satisfied that we are going fast enough?

General BARCLAY. I believe we could go with greater assurance. We have had our programs funded so that we can make progress. There are some things, however, that would be desirable to give greater assurance and reliability in our programs, which we have not been able to do under the present funding.

Mr. ANFUSO. Has the Army suggested other projects for which it has been unable to get the funds to carry them out?

General BARCLAY. Yes, sir, we have. We have made proposals to both ARPA and NASA, and we have further projects under study, at their request, for presentation to them.

These studies, of course, have not been given to ARPA for their consideration and decision as yet.

Mr. ANFUSO. You have not as yet given them out?

General BARCLAY. Not as yet; that is correct.

Mr. ANFUSO. But you have them under consideration?

General BARCLAY. That is correct.

Mr. ANFUSO. All of which, if you got the money for them, would enable us to move faster; is that the idea?

General BARCLAY. I feel if our long-range objectives are established and carried forward with resolution and with adequate funding that in a few years we will be in our rightful place in this area.

Mr. ANFUSO. Thank you very much.

Mr. Chairman, at the request of Mr. Sisk, I promised I would ask two questions.

The CHAIRMAN. Can we recognize Mr. Roush? I want to recognize as many as I can, and then we will get your questions in.

Mr. ROUSH. Mr. Chairman, I think I can speak loud enough so that I can be heard without the use of the microphone.

General, there is a question in my mind. I am an old infantry soldier, and I realize the importance of being able to control the weather, and you spoke of the possibility of a breakthrough.

Is there a definite relationship between the control of space and this possibility of controlling weather? Do we have any evidence of that yet?

General BARCLAY. Mr. Congressman, our weather of course exists primarily up to some 80,000 or 100,000 feet. Space we normally con-

sider as beyond that. Our study of the weather, cloud coverings, and the formation and movement of air masses and winds, which we hope to achieve when we can look down on our earth and on our weather in the making, we feel may give us means of controlling weather.

Mr. ROUSH. In other words, right now you are concerned about the ability to predict the weather, which you hope will eventually lead to the possibility of the control of weather?

General BARCLAY. Yes, sir; when we can accurately predict it, we think we may find means of controlling it.

Mr. ROUSH. And if we have means of controlling it, it will have great peacetime significance as well as wartime significance?

General BARCLAY. Yes; that is correct.

Mr. ROUSH. Maybe I won't need the dams which I am hoping my area will get.

Thank you, Mr. Chairman.

The CHAIRMAN. Any further questions?

Mr. HECHLER. Mr. Secretary, one of the witnesses indicated yesterday the desirability of a more centralized, single U.S. space agency. This witness expressed some concern as to whether this program might be bogged down by bureaucracy.

I gather from your testimony that you feel that the coordinating efforts of existing agencies are sufficient under the arrangement we now have.

I wonder if you would care to comment on the proposal that an agency designed along the lines of the Atomic Energy Commission, with a military applications division, can be created in order to pull this program together or do you feel that the current administrative arrangements are satisfactory?

Secretary BRUCKER. I feel that it is in an early stage to be talking about reorganizing what is in existence at the present time, and I approach my answer to you in that way.

I believe that what we have now should be lived with, implemented, assisted, coordinated, and so on, until we see what the bugs are and the problems that arise. I don't believe that it is wise at this stage to engage in reorganizing and changing the structures.

I think now the thing to do is live with what we have, get along with it, work with it, find out its deficiencies and inadequacies and then your committee and others will recognize that and make the proper modifications and changes.

Now, in the sense of the AEC, we have one of the parallel agencies now. It is the Civilian-Military Liaison Committee, with members, of course, from the Department of Defense and each of the services, who meet and report monthly. That liaison committee will do a lot to keep this thing in balance. That is patterned after the structure of the relationship between the Defense Department and the AEC. So that is a parallel that has been transplanted over.

I do feel that there are things, of course, that can be improved upon as time goes along, but at the present time I am emphatically answering to you that I think this is a satisfactory arrangement.

The statute is well founded, and the agencies that you have with the Space Council, the Space Administration, and ARPA with Defense, and the services under that, this is a working arrangement. If men of good will work together with it, we can get along and make great advances, much more than we have up to date.

Mr. HECHLER. Thank you.

The CHAIRMAN. Any further questions?

Mr. KING. Mr. Chairman.

The CHAIRMAN. Mr. King.

Mr. KING. Exploring this point about which you have just testified a little further, to a layman it does seem a little singular that you have three branches of our service and now, of course, NASA, making a fourth, all engaged in a space program, with the inevitable overlapping, and there is bound to be duplication, as you testified.

I just raise the question, is that not resulting in a duplication of effort that raises the costs rather appreciably and something the Congress might be interested in?

Secretary BRUCKER. I think you raised a good point, duplication of costs. At the present time ARPA is not an independent agency in the sense that it is an overlap on the three organizations. It is more of a monitoring organization so it does not spend money of its own for itself but for projects which it approves and releases.

Now most of these projects, if not all, are released to one or more of the military services. We each have sort of a permanent liaison by representation at ARPA. ARPA has members from each of the services in its employ and without reference to the service they are all in on the question of what projects are being applied for and what projects are being let to the different services. They all know what the other services are promoting or suggesting. Now ARPA is very careful and I want to give ARPA credit for that. They have been very careful to see there is a minimum of overlapping. There is bound to be some overlapping. There cannot be a clear line of demarcation on every one of these projects because they have elements of similarity and I do not want to mislead you, but to the limits of ARPA's ability and the limits of our ability in the service I think it is going along very well.

I do think, of course, that the Secretary of Defense should constantly review the operation of the ARPA to make sure that what Congress directs is carried out and that every dollar is saved. But, the fact that a thing overlaps in the research and development field at this stage is not dangerous if it is not perpetuated for any length of time and if the followup steps are taken at the proper time by the agency concerned.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. General Barclay, you referred to the communications objectives of these equatorial satellites, which will go around this 22,000-mile orbit, as I understand it, and will be sort of stationary. What is to prevent the Russians from shooting them down once we get them up there?

General BARCLAY. That, of course, is always a possibility that any target is susceptible to, if they have the capability they can do that.

Mr. DADDARIO. Would it not seem, then, that they would have that capacity, and this would be one of our objectives that we are spending money on which should be directed in another direction? For example, we could have such an observation post on the moon where you could set up some sort of defense against this particular type of counterattack, countermeasure.

General BARCLAY. I feel sure the Russians have given consideration to that possibility. If I may, I prefer to respond in detail in executive session.

The CHAIRMAN. Mr. Anfuso, you have some more questions.

Mr. ANFUSO. Yes, Mr. Chairman. I want the record to show I am asking these two questions on behalf of Mr. Sisk who had to go on the floor.

Mr. Secretary, since your agreement of December 3, 1958, have vou issued supplemental or implementing instructions to ABMA regarding work for NASA?

Secretary BRUCKER. I have conferred personally with the head of that agency, the Army Ordnance Missile Command, that is General Medaris. Then his next officer in command is the Army Ballistic Missile Agency commanding officer, General Barclay. I have always talked to them. I have also talked to Dr. von Braun personally with reference to it and likewise this has been paralleled by the Chief of Staff and by the Vice Chief of Staff with respect to our ordnance personnel and others down the line. Because of the fact that the Army Ballistic Missile Agency is given such a direct line, it does not have to come up through channels and the top personnel have access directly to my office. Because of that, our relation is so close that we have not issued formal printed or written regulations but there are perfectly clear oral instructions as to how that shall be implemented.

I think General Barclay ought to add just a word to that.

General BARCLAY. Yes, Mr. Secretary. To put it succinctly, Army policy has been established by the Secretary and as we express it, that Army policy is "Never say 'No' to NASA."

Secretary BRUCKER. Can I just add one word. We may have given a wrong impression here. The request of NASA does not even have to go through me. It can go directly to the Army Ballistic Missile Agency and save redtape.

Mr. ANFUSO. That is very fine. Thank you, Mr. Secretary.

Now, General Barclay, what are the advantages of utilizing the so-called arsenal system for military missile development over the industrial system?

General BARCLAY. Mr. Congressman, we feel that it is an inseparable obligation of those of us in the service to do two things with respect to the development of our weapons.

First, we must insure that the soldier in the field gets the best possible weapons which our engineering, our science, and our technology can produce.

Secondly, we feel that we owe to the taxpayer the obligation to assure that he gets the maximum benefit for each of his dollars which are spent in our national defense. To assure that we can meet those two objectives and obligations, we must have within our own organization and within what I think is erroneously called the arsenal concept, and should more correctly be called the engineering concept, we must retain capable people who are able to evaluate the product of our contractors and the people who do our development work and who can determine that we are paying a fair price for what we get and that the soldier will get the best weapon which we can conceivably develop for him.

Mr. ANFUSO. Now, lastly, can you think of any disadvantages?

General BARCLAY. There are probably disadvantages from the commercial aspect of people who would like to take over the supervision of our weapons systems but whom we feel cannot do so with the objectivity which is necessary to carry out our responsibilities.

Mr. ANFUSO. Thank you.

The CHAIRMAN. Mr. Mitchell, do you have a question there?

Mr. MITCHELL. I will be very brief.

The CHAIRMAN. The Chair plans to recess until 2:30. We have witnesses in executive session that are very important. So after this we will adjourn until 2:30.

Mr. MITCHELL. I will be very brief, Mr. Chairman.

Mr. Secretary, as a matter of information, the projects assigned to you military-wise come from ARPA, is that correct?

Secretary BRUCKER. Yes, the military projects come through ARPA.

Mr. MITCHELL. The civilian space projects are designated by NASA?

Secretary BRUCKER. That is correct.

Mr. MITCHELL. Now you described—and I think most graphically—how this operated by saying it was interlocking; you said there was a free flow of information, a daily exchange between your projects that are designated by ARPA and those designated by NASA.

What I would like to know is, Is there any interexchange of information, that is, what you learn on an ARPA project, is NASA so advised of this advance?

Secretary BRUCKER. Yes, I meant to imply that, sir, that NASA gets the benefit of it and ARPA likewise gets the benefit of the other. With both it is an interlocking relationship, reciprocal, and I would like to have General Barclay give the word on that one.

General BARCLAY. Yes. As an example of the coordination that takes place between ARPA and NASA, on our Juno V booster unit which was assigned as an ARPA project, the NASA agency has followed that very closely. They have been sitting in on our technical meetings and they are contemplating application of that same booster to some of the projects being undertaken by NASA.

Mr. MITCHELL. Thank you very much.

The CHAIRMAN. Thank you very much.

Mr. Secretary, unless you have a further statement, the committee wants to thank you very much for being here.

Secretary BRUCKER. Mr. Chairman, I do not want to be facetious, but the question was asked about mythology and Juno.

Mr. MILLER. Aerospace was the mythology.

Secretary BRUCKER. I would like to say Juno is reputed to have been the wife of Jupiter and Jupiter is pretty closely associated with the Army.

The CHAIRMAN. That is well said, Mr. Secretary. We want to thank you very much for coming here and helping the committee, and General Lemnitzer for being here, and General Barclay for being here also. We appreciate your assistance and we do need all of the help we can get. This committee is a new committee, it is conscientious and earnest in its endeavors, and we are going to make a good record for the committee.

Now unless there is further business, we will adjourn until 2:30. It is not necessary for you gentlemen to come back unless you so desire.

The 2:30 session will be executive session, not open session.

Secretary BRUCKER. Mr. Chairman, may I just say one word?

The CHAIRMAN. Surely.

Secretary BRUCKER. I am very happy to learn that you, sir, and some of the members of the committee have accepted our invitation to go to the Redstone Arsenal to see the work that is done there next week. I welcome this visit. I want to let you know that this is very pleasing, not only to the Army but to everybody, to know that you would take the interest, and I think others who have not indicated their willingness to go will think it over or hear about it, because we like to have you people see what is going on down there.

The CHAIRMAN. Mr. Ducander, did you want to make a statement on that?

Mr. DUCANDER. I would like to find out from the members who are planning to go.

The CHAIRMAN. When do you plan to leave and when will you get the committee back?

Mr. DUCANDER. We will leave at 2 o'clock p.m. from Bolling Air Force Base on Wednesday, the 11th, go to Cape Canaveral and spend the night and the next day until 4 p.m.; leave there and go to Redstone where we will spend Thursday night and all day Friday and Friday night and until noon on Saturday; return to Washington at about 4 o'clock in the afternoon, Saturday afternoon, the 14th.

I would like to find out from the members here who would like to go. I will call the roll.

Mr. Brooks.

The CHAIRMAN. Yes.

Mr. DUCANDER. Mr. Anfuso.

Mr. ANFUSO. Yes.

Mr. DUCANDER. Mr. Mitchell.

Mr. MITCHELL. No.

Mr. DUCANDER. Mr. Hall.

Mr. HALL. Yes.

Mr. DUCANDER. Mr Hechler.

Mr. HECHLER. Yes.

Mr. DUCANDER. Mr. Daddario.

Mr. DADDARIO. I will have to check the Saturday date.

Mr. DUCANDER. We will check with you later.

Mr. King.

Mr. KING. Yes.

Mr. DUCANDER. Mr. Roush.

Mr. ROUSH. Yes.

Mr. DUCANDER. Mr. Fulton.

Mr. FULTON. Yes.

Mr. DUCANDER. We will check the offices of those who are not here.

The CHAIRMAN. We want to thank you. We will accept your invitation. I hope all of the committee will go.

(Whereupon, at 12:28 p.m., the hearing recessed, to reconvene at 2:30 p.m., the same day.)

AFTERNOON SESSION—EXECUTIVE SESSION

The committee met in executive session at 2:30 p.m. in the caucus room, Old House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The committee will come to order. These proceedings are in executive session.

Mr. Ducander, has the committee room been cleared?

Mr. DUCANDER. As well as we can clear it, sir, except for the people back there.

[All were subsequently cleared out.]

The CHAIRMAN. I would suggest this, gentlemen. I do not want to insist on it, but it would be a little easier for everyone to hear if you would come down here. We are short of Republicans; can we temporarily help them out.

Now, Dr. von Braun, would you come up. You are the prime witness at this hearing and we have scheduled you for this particular hour, because we know it is difficult for you to get up here and local witnesses sometimes we can hear later on. We are pleased to have you again before this committee.

The people of the United States think you are doing great work in this respect and we consider you the outstanding authority on missiles.

Now do you have a prepared statement, Doctor?

STATEMENT OF DR. WERNHER VON BRAUN, DIRECTOR, DEVELOPMENT OPERATIONS DIVISION, U.S. ARMY BALLISTIC MISSILE AGENCY

Dr. VON BRAUN. No, sir; I do not. I was told that you wanted to have a little introduction to the general problems of space flight and I have brought a few slides along. We have set up a projector and screen.

The CHAIRMAN. Suppose you take over and proceed just as you wish to do and make it as informal as possible.

Dr. VON BRAUN. Right, sir. How much time will you give me for this? Twenty minutes?

The CHAIRMAN. I think we are safe in saying about an hour, from 40 minutes to an hour. We will give you any amount of time. The committee wants to hear you in extended session, but the trouble is there is at least one rollcall and maybe two rollcalls coming up this afternoon and we would not want that to interrupt you in your testimony.

Dr. VON BRAUN. What I had prepared here is a very informal talk involving, I think, 18 or 19 slides, lantern slides which I have selected to familiarize the committee with the fundamental problems involved in all major areas of space flight. I will keep it as unscientific as possible.

Can you hear me if I stand here?

The CHAIRMAN. Yes, sir; if you speak slowly.

Dr. VON BRAUN. This first picture shows the fundamental idea behind the meteorological satellite, a satellite designed to keep us informed about the weather all over the world. Meteorologists believe that the one factor that influences the weather on the Earth more than anything else is the cloud coverage.

Now there are some areas of the Earth covered with clouds whereas others are clear. Those clouds reflect the sunlight permitting only a small portion of the Sun's radiation to get down to the ground whereas the rest is reflected back into outer space. So a cloud as seen from above, as you all know from riding airliners, looks very bright, whereas underneath it is dark.

Now, the distribution of the cloud coverage of the earth, therefore, controls the weather. But, unfortunately, since 70 percent of the earth's surface is covered by water and even the land areas are partly thinly populated and not all covered with weather observation stations, we know very little about the total cloud coverage of the earth, its geographical location, and how it changes.

Now, with one simple satellite going around the earth, say, 16 times a day and equipped with a television camera relaying information continuously to the ground, we can provide this information. With several such weather satellites, of course, we can virtually retain continuous uninterrupted knowledge as to change in this overcast. Meteorologists believe that with such satellites it would be possible to really dramatically improve our capability of forecasting the weather.

The military indications, as well as the advantages accruing out of this for agriculture, and the tourist trade, would be rather obvious.

This slide depicts the satellite above the surface of the earth, discerning the cloud coverage and the clear areas.

The next slide, please.

This next slide shows another application of satellites which we all feel has a tremendous commercial, as well as military, importance. It is a system consisting of three satellites spaced 120° apart in one orbit, at a distance from the earth of approximately 22,000 miles. This orbit at this tremendous altitude of 22,000 miles, would go around the earth at the plane of the Equator and at this altitude the period of revolution of each of these three satellites happens to be exactly 24 hours. With these satellites flying in the direction of the earth's rotation, that is, from west to east, each will be stationary over a certain point on the earth's Equator.

Now, in view of the distance of this orbit from the surface of the earth, each of these three satellites will be able to see the other two. They will not be obstructed by the earth because the earth is too far away. Also, every point on earth between the North Pole and the South Pole will always see at least one of these satellites. Over the Equator it might be right at the zenith, or there, or there [indicating]. Over the North Pole it will be right at the horizon, the same at the South Pole; but at any point in between every point on earth will be in optical line-of-sight contact with at least one of these three satellites. For this reason it is possible to establish a radio link with line-of-sight radio from a point on the earth up to the satellite, from this satellite to another satellite, and from this satellite to another point on the earth.

Now, you all know that the spectrum of radio frequency is so overcrowded that it is virtually impossible to add any more communication links to the existing radio spectrum. In the shortwave region where the waves do not bend around the earth and follow the curvature of the earth, but where you can communicate only with line-of-sight contact, the spectrum has almost unlimited capability of taking on more messages, simply because you can stack the frequencies tighter. For that reason a system of research satellites opens entirely new avenues for worldwide communications.

It can be used for worldwide radio, worldwide television hookups, worldwide facsimile, messages, wires, telegrams, everything. The traffic volume handling capability of such a system depends only on the amount of weight that we are willing to install here, and it is clear—investigations prove this without any doubt—that a satellite weighing between 5,000 and 10,000 pounds going around at this altitude, a system of three satellites would handle all of the mail volume of the entire earth.

Now the price to set up such a system will be negligible, or almost negligible in view of the fact that the vehicle cost to carry it up there can be amortized against many other projects also, if you compare it with the price of, say, a submarine transatlantic cable which, of course, has only a very limited volume capacity. I believe that such a satellite system, which, incidentally, is under active development today in the United States, can be a tremendous moneymaker too and may actually provide the sources of revenue to finance the rest of our space programs.

Just imagine if you could charge a penny a word for this kind of service. I would like to mention that aside from the commercial possibilities of this system, it has tremendous military applications and it is for this reason that the present 24-hour satellite system—communications satellite system—is being sponsored by the military services.

It has been taken over by ARPA and the immediate objective at the moment is to provide the Strategic Air Command of the Air Force the Submarine Command of the Navy and the Army commands, Tactical Army commands with communication channels.

Can I have the next slide, please.

The next area that I would like to cover in my presentation here is the problem of lunar problems and, more generally speaking, the exploration of the moon. You know that the United States has tried several times now with the Pioneer probes to send a sample, a so-called space probe, past the moon. Unfortunately only two of our probes have worked fairly successfully, but none of them have gotten there. Both of the Air Force's Pioneer I, and the Army's Pioneer III fell short of the velocity necessary, and went only about a third of the way to the moon. With 3 percent more velocity, the moon's vicinity could have been attained. The Russian's Lunik actually did the trick.

This slide shows the flight path which we planned for our Pioneer III space probe and it is planned again for our forthcoming Pioneer space probe.

Transport time of 34 hours has been figured. With a little more velocity we can bring this time down by several hours and by not

going quite as high a velocity we can still transfer a rocket to the moon with a longer transfer time, up to a 100 hours, but this particular flight time of 34 hours was appealing to us because a flight to the moon would be close to the moon at the time that our tracking station in California would have the moon in optical line of sight.

The CHAIRMAN. I am wondering if you stood up a little closer you could still point and we could hear you more effectively and it would not be as hard on you. If not, you can resume your position.

Dr. VON BRAUN. Suppose I take the microphone and pull it as far as I can.

The CHAIRMAN. You could have somebody else do the pointing for you.

Dr. VON BRAUN. These early lunar probes, of course, had the sole objective of going toward the moon in a one-way trip. The moment we consider putting people into such rockets it will be necessary to bring them back.

The simplest type of a manned lunar expedition will be a trip around the moon not involving a landing on the moon with an ensuing return flight in the atmosphere. This is depicted in the next picture.

You see the earth here and over on the right corner—would you move the slide a little bit—there is the moon. So here you see the trip out to the moon and if you time this undertaking properly, the moon will be at the remotest point when the rocket gets there and the rocket will then simply fall back toward the earth and its velocity will increase again on the way down. It will tangentially sweep into the atmosphere and then the most harassing part of the trip begins; to decelerate the rocket from its initial 25,000 miles an hour velocity at which we enter the atmosphere, down to subsonic speed and landing. The trip around the moon not involving a landing on the moon is much simpler than a landing on the moon simply because it requires two fewer maneuvers. There will be no landing on the moon and no departure from the moon. There will simply be a departure from the earth, building up the necessary speed to go out to the moon—a correction maneuver involving very little propellant supply to place the rocket into the right position to get back to the atmosphere at the right angle.

A voyage to the moon involving a landing and takeoff from the moon is far more involved, because all of the propellent that is required for the landing on the moon and the departure from the moon must be brought up there to begin with. Therefore, the initial rocket that takes off from the earth will be much larger.

May I have the next slide, please.

This slide shows what such a rocket might look like. You see it there in the right corner of that lunar landscape. Note that the rocket is not streamlined. There is no need for aerodynamic streamlining for outer space rocketships simply because there is no atmosphere. The way to build such ships would be that the tanks and the crew in a cell and the rocket engines will be freighted up to the orbit where all of the parts are put together, then the rocketship is fueled and it takes off from the orbit around the earth and returns to that orbit around the earth again. It will never get into the atmosphere. Return to the atmosphere will be done with a different type of vehicle. So, for a voyage to the moon and back, we will use for the first time

deep spaceships, which is an entirely different breed of cat from what we are used to.

May I have the next slide, please.

I mentioned that for deep space operations of a more ambitious nature—that is, round trip to the moon and even to the planets—it will become necessary to separate the undertaking into two different phases. We will have one kind of vehicle solely designed to carry people and cargo into an orbit around the earth. In this orbit the people brought up there will take the cargo out of the other ships and assemble it to build one of these nonstreamlined deep spaceships which are solely designed for the voyage to the moon or other planets but not for travel in the atmosphere. The vehicle you see on this slide is designed for the first part of the mission, to get people and/or cargo up to the orbit. It will be a multistage rocket.

The first stage will go up to about that first platform [indicating]. Then comes the second stage to the next platform and the wing unit sitting on top of it will be the third stage. Only the third stage will get up into the orbit and only the third stage has the capability of landing again at the launching site.

The next slide shows what the third stage or top stage will look like when it lands again at the airport. It will be essentially a supersonic airplane, and upon its approach it will put its flaps out and land like a normal aircraft. Not all of these orbital supply rockets will have wings, however.

If no people are involved, you can use a nonwing top stage designed to remain in orbit and maybe even serve as tankage for a deep spaceship. It will have no return capability and can therefore bring much more useful payload to the orbit because it is not mortgaged with heavy wings, landing gear, pressurized cabins, and the like. But the basic vehicle will be the same. There will be the same first and second stages. So the typical orbital supply vehicle will be a big first and second stage on which alternately either a oneway top stage can be added for the sole purpose of carrying supplies or fuel to the orbit, or a manned version that has return capability but cannot carry as much payload.

May I have the next slide, please.

Aside from the vehicular aspect, space flight involves a number of medical problems. One is the high acceleration. To build up a speed of say 25,000 miles which is necessary to go from here to the moon, we have to provide a very substantial acceleration for several minutes simply to get that speed.

Now any rocket when taking off from the ground will be heavy and for that reason the initial acceleration will be quite low. It may be less than 1 g.—on top of the 1 g. we are subjected to as we walk around the earth. As the missile consumes its fuel it becomes lighter and the thrust remains constant and the acceleration will go up and toward the end of the burning time of each stage the acceleration may be as high as six or seven g.'s.

Of course, once a stage is dropped and the next stage takes over it begins again at a lower acceleration, so the acceleration pattern will follow such a curve, a sawtooth curve. Every time the acceleration goes up it drops down again and goes up again.

Now to train the crews on how to take these accelerations and how to operate and function efficiently under these high accelerations, centrifuges are in use. We use the centrifuges simply to whirl the man around and you can present him with all kinds of tasks to perform under the acceleration. Such tasks may be simple in nature. For example, you can ask the man to make a little sketch and then see how that sketch deteriorates as the acceleration goes up and the thing spins faster, but you can also cast what we call "synthetic disasters" on his dashboard which are created with a computer on the ground and which create on his dashboard the impression like something in the rocketship he seems to be flying went wrong. Then under 6 g. acceleration the man has to use the right judgment and push the right buttons to remedy the source of trouble.

All this, of course, is a synthetic thing, but it is very suited to analyze the proficiency of the man under these conditions. This procedure is in wide use today.

The next slide deals with an entirely different problem. You see a little white mouse here sitting in a glass jar and this laboratory assistant is watching him. Over to the right side is a gage which measures the airflow that is continuously being pumped through this jar.

The purpose of this experiment is to investigate what biologists call the problem of life in the pen. It simply means what happens when you enclose a biological specimen, for example, a mouse, into a limited confinement over a long period of time, say weeks or months so that the mouse must continuously breathe again the air it has been exhaling, when the mouse eats in this thing, performs its sanitary functions and everything, what happens to the air. Is it possible to treat the air chemically over a long period of time so that there will be no actual poisoning due to the fact that some poisons accrue in that air circuit which will ultimately kill the mouse.

Just to give you an inkling of this problem here in a normal household it is known that about 29 different toxic agents are formed in routine operations. For example, when you fry an egg and some of the egg white is burned in the frying pan, a very potent poison called acrolein is formed. If this acrolein were formed in this environment and the man would breathe it over and over again 24 hours a day, 7 days a week, he would die from the acrolein from the frying of one egg.

In a normal household there is no problem, because if you burned an egg, the housewife would cough, open the window, and the poison would go out. Of course with suitable filters it is possible to take all of these poisons and toxic, offensive odors out of the air stream, but you have to know how to do it.

The submarine *Nautilus* is confronted with very much the same problem. They have a crew of almost 120 people in there. They have made long cruises, and I think they still have a problem that after 30 days people just hope for the day when the conning tower will be opened and some fresh sea air get in, despite all of the chemical cleansing agents they have. So this is the problem of life in the pen.

The next slide deals with the problem of vacuum. I mentioned for deep-space operations it will be necessary to assemble special deep-space rocketships out of parts shipped up there by orbit and supply rockets. This means that crew members and fitters will have to leave the rocketship to perform these assembly and fitting operations. Since

there is a vacuum outside they have to be properly clad so their bodies would not explode under the internal pressure. One answer to this problem is the full pressure suit. * * *

For fitting and assembly operation in the orbit, the question arises, however, whether such a unit tailored after the human frame is really what is needed. This man is not only encased in a pressurized shell, his torso and the rest of his body, but even his hands stick in pressurized gloves. Each finger is pressurized, and the question is, can a man really perform a complicated assembly job in this kind of garment?

The answer to this question may be the so-called bottle suit which is shown on the next picture.

Here we have an entirely different idea. The man is no longer encased in a pressure suit fashioned after his body. He, rather, sits in a rigid bottle. It almost looks like a Coke bottle, and in that top, that dome, you see his head. Within this bottle he is strapped to a board, and around his chest is a panel with manipulators into which he can stick his hands.

There are seven arms protruding from this unit. You can see two of them. These are artificial arms [indicating]. He can operate these arms with manipulators from the inside, and by moving his fingers and twisting the manipulators, he can operate the tool which is attached to the end of the arm.

You probably have seen these manipulators used in the atomic energy projects, where people have to pour the contents of one bottle into another bottle with a radioactive fluid which they are not supposed to touch. Well, the idea is the same. In a way there is a similarity between this concept and the artificial arm of an amputee. The advantage of this concept over the one shown in the previous picture is that you really provide the man with tools at the business end of these artificial arms. What you need there is really not five fingers, but what you need is a drill or pliers or a device to rivet something or to weld something, and you can provide all kinds of special attachments to these arms in accordance with the job at hand.

Of course, in order to maneuver himself around in space, the total suit must also have a capability of positioning itself in the right attitude. So the man will have a joy stick similar to that used in airplanes which, by pushing down, will create an operation of gyroscopes, so the suit moves over, like this [indicating]. He can control his attitude in this way.

There is also a built-in rocket plant which can exert a thrust of a few pounds in either the downward or upward direction along the longitudinal axis of the suit, and from this way he can move away from the ship and move back to the ship.

Needless to say, there will be built-in walkie-talkies and built-in air-conditioners and all kinds of things in this bottle suit.

An amusing aspect, as it turns out, one of the most tricky problems in these pressure suits is a man can't even scratch himself. When you are completely encased in a pressurized suit, you can't scratch yourself, blow your nose, things like this. In this suit you can. For the well-being of the man and his proficiency in these little things, this may be important. A man can even eat a sandwich in this bottle.

So much for the biological aspect.

Now, may I have the next slide?

We now come to the concept of outer space in more general terms.

Outer space is one of the most frequently used words and one of the most abused names these days, so it might be proper first to try to define it.

I don't know a better definition than the one my good friend, Jim Van Allen coined the other day when he said the definition of outer space was that outer space is the hole we are in. In other words, surrounding the Earth is outer space, and we are right there in it.

On this picture you see the Sun on the left side, with the planets. You begin with Mercury, Venus, and then comes Earth. That little rather insignificant thing there is the Earth. Then comes Mars, and then comes the big one, Jupiter, Saturn, and then comes Uranus, Neptune, and, way out there, Pluto.

Our first objective, of course, in outer space, after we have established satellites, is to go to the Moon. The Moon is that tiny little speck next to the Earth that goes around the Earth.

I would also like to point out that the relative distances, of course, are entirely out of proportion. Just the sequence is right.

Now, we have seen by a previous picture what it takes to go from the Earth to the Moon. The moment we want to go from the Earth to another planet, the situation becomes quite different, because both the Earth and your target planet are going around the Sun, and for that reason you cannot go directly as a crow flies but you have to take into account that we have already an initial speed, namely the speed of the Earth as we depart from the Earth.

Now, the next chart shows this in a little more detail. You see the Sun in the middle of this thing, and a little bit to the left of the Sun, at E–1, is the Earth.

Now, the Earth goes around the Sun in a counterclockwise direction. Now, so does Mars, which is shown as the red planet in the outer orbit. To go from the Earth to Mars in a most economical flight path now requires the following: You have to impart the speed to the rocket in the direction of the Earth's own orbital motion around the Sun, which is a counterclockwise direction, and if that speed is high enough, it will bring the rocket out in this elliptical transfer flight path which will intercept Mars at M–2, 180° later.

Why does a rocket go through this elliptical flight path?

Well, it is easy to see. At E–1, the Earth goes through a circular orbit, and the circular orbit is simply defined by the condition that the Earth has a sufficient horizontal velocity so that the centrifugal force exactly compensates the Earth's weight in the gravitational field of the Sun, so the Earth just goes around in nearly circular orbit.

Now, if you could accelerate the entire Earth by approximately 1 mile per second over and above the 90 miles per second that the Earth is doing already, then the Earth, itself, would also go into that ellipse, because now with the distance of the Sun at first at least remaining constant, the centrifugal forces would increase; they would overcome the gravitational field of the Sun, and as a result the Earth would further recede from the Sun. It would coast upward in that ellipse and reach the point M–2, the highest point of that ellipse with respect to the gravitational field of the Sun. This we call the aphelion of this ellipse. If it were left to continue, it would follow

through the second leg of this ellipse and go back to E–1 and go down to the lower orbit of the Earth again and remain in this eccentric ellipse forever.

Now, we cannot do this with the whole Earth, and we won't do it, but we can take a portion of the Earth, for example, a little rocket ship, and fire it up in the direction so that when it leaves the gravitational field of the Earth it is flying exactly forward in the same direction as the Earth's own orbital motion around the Sun. In this case only the rocket ship goes in that ellipse.

Now, we can time the whole business in such fashion that when we get to M–2, to that point down there, that the planet Mars is also there, so that we just don't touch the orbit of Mars but make sure that Mars is really there for a rendezvous.

Now, you can figure out this is only possible if Mars is at the point M–1 when you take off at E–1, which means it must be 44° as seen from the Sun, angularly ahead of the Earth. This is simply so because it takes Mars 261 days to go from M–1 to M–2, and it takes the rocket ships also 261 days to get from E–1 to M–2. So this is the timing aspect of the whole thing.

Now, let me show on the next slide what that means as far as the departure from the Earth is concerned.

You see here the Earth, and I mentioned that such trips will be carried out not from the surface of the Earth but from an orbit around the Earth, so you see the Earth here, and that ring surrounding the Earth is the orbit on which we depart.

Now, at this point we can fire the rocket and then follow a powered path that terminates at the point of cutoff. Here the maximum speed is reached to go to Mars, and from there on the free coasting flight begins, unpowered.

The rocket follows this so-called departure hyperbolic escape leg and will ultimately fly to the right, which is parallel to the direction of the Earth's orbital motion around the Sun. This is how we get into the orbit.

Now, 260 days later the rocket will then in that solar half-ellipse approach Mars, and this we see on the next slide—first, this is the power maneuver. This is what the two rocket ships would look like that depart from the Earth in that power maneuver which built up the sufficient speed to escape from the gravitational field of the Earth and enter that solar ellipse.

Now, 260 days later—next slide please—the ship will approach Mars, and here the situation is as follows:

Mars moves through its own orbit at approximately 11 miles per second. It is a little slower than the Earth, but the ship that has coasted out there to Mars has lost velocity because it has been going uphill in the gravitational field of the Sun all of the time, so it is even slower than the 11 miles per second, approximately down to 10 miles per second. So as it gets to Mars, Mars will now overhaul the ship from the rear, and as seen from Mars, the ship will fall into the Mars gravitational field. If we position it properly at the beginning, it will fall in this so-called approach leg, the capture hyperbola, and at the point R–T, we will decelerate the speed and induce the ship into the orbit around Mars, and that is where our nonstreamlined ship

will remain for the period of exploration of Mars, itself, until it will depart to Earth again from that orbit around Mars.

In this fashion we need not carry the return craft. We just park it in the oribit, and then take the special vehicle.

The next picture shows what such an approach to Mars would look like. The ships are sweeping into this hyperbolic flight, tangentially past the surface of Mars, and they will then fire the rockets, using them as brakes, and introduce themselves into the hyperbolic orbit around Mars.

You see there is a big ship with wings on the top and an apparently smaller one farther down. This ship in the foreground is a one-way vehicle. It is designed to fly only from an orbit around the Earth to this orbit around Mars. What arrives there is only a winged vehicle, capable of landing on the surface of Mars and departing from the surface of Mars again and returning to the orbit. The other ship, the one underneath, has no Mars landing capability. It is a round trip ship. It has all of the fuel it takes to go out to Mars and back to the Earth, but it has no capability of landing.

There is some advantage of breaking up such trips into two such vehicles, and fundamentally the idea is very much the same that you would use in taking a fleet tanker along with the Navy. When you have a battleship and the battleship carries a lot of other weight and you want to extend its radius, you can take a fleet tanker along and when the battleship is dry, the fleet tanker comes alongside and transfers its fuel to the battleship, and then the fleet tanker either goes to some nearby port to get enough fuel to go home or, in theory, you could even abandon it. But even by abandoning it, you would stretch the range of the battleship.

We actually abandon the one-way ship in space flight. That seems to be far more economical than to try to bring it back.

So by breaking a trip down into two ships, one for the one-way trip, that brings plenty of useful payload to your target, the planet, and the other equipped with enough fuel for the round trip but no payload. You can have your cake and eat it, too. You have enough fuel to bring you home and at the same time you can bring substantial payloads, hundreds of tons, to other planets.

So this is the idea.

The next picture shows the winged vehicle after it has landed on the surface of Mars. Note that its front portion has been separated from the winged after portion and has been erected. It is this front portion which carries enough fuel to go back to the orbit around Mars.

Fortunately, due to the fact that Mars is a much smaller planet than the Earth, it requires much less propellant to get from the surface of Mars to orbit around Mars, and this can be done with a one-stage vehicle.

There are also ground vehicles brought along. You see them to the left. This is something science writers very often overlook. There is no point in sending some people to Mars unless you give them some equipment along to really do some useful work there and to conduct some research.

One of the most important things they will need is housing, so you see that little pressurized tent down there in the valley, this hemi-

spherical thing. It is like a plastic dome used on the DEW line, with a radio station and everything.

There is also ground transportation in the form of track-laying vehicles, with a pressurized compartment on top, which will be used to drive around on Mars.

It would be advantageous of course to have nuclear-powered vehicles, but they can even be driven with chemical energy.

The return trip will be carried out by the crew members. The ground equipment will be abandoned, and the crew will get into the rocket and fly back to the orbit, where that other ship, the nonwinged, round-trip ship, has been circling, and they will go back to the earth, in that other ship. In fact, they will not go back all the way to the surface of the earth but only return to the orbit around the earth, and from there one of these winged, upper stages that I showed in one of the previous slides, used in the orbital supply operation, will provide the final portion of the trip back to the surface of the earth.

This slide here shows quite an interesting aspect. Such a Mars ship as used in this particular scheme would weigh 1,870 tons when departing from the orbit of the earth. After arrival in the Mars orbit, it will be down to 218 tons. Now, the one-way ship—that weight will be abandoned, and it will be a practical, useful payload, that is in the second column, whereas, the round-trip ship will still weigh 237 tons when it returns, mainly because the people and some cargo have been returned to the main ship, and finally when it returns to the earth, the weight is down to 38 tons.

So you see you take off with a heavy, big vehicle, and what comes back to earth is the bare minimum of what is necessary to bring the men back alive.

All of the food has been eaten up, the air has been used up, the fuel has been burned up, and there is virtually nothing but the passengers and the empty cabin.

This ends my presentation, sir.

The CHAIRMAN. May I ask you a question, Doctor?

Why do you need those wings on that plane out there in space?

Dr. VON BRAUN. You don't need it in space. You need it in order to land on Mars. The planet Mars has an atmosphere which is not quite as dense as ours but it is sufficient to permit an aerodynamic landing on the surface of Mars.

The CHAIRMAN. You would need that as you reenter atmosphere?

Dr. VON BRAUN. Yes; you would finally glide down on the surface of Mars and land on skids on the surface of Mars.

The CHAIRMAN. Are there any questions?

Mr. FULTON. We want to compliment you, Doctor, for your fine work, and we in America feel that you are one of our best assets.

I remember when you were before the select committee that you said that you could make a moon shot, and I might say to you you were the one who put the first American shot in orbit, and it was done 84 days after you said you could.

I think that is a real accomplishment and should be in the record.

There is one question, though, that I would like to have you explain a little, and that is temperature variation between the sun-reflecting side and the shady side, either the space suit or the spaceship, how

do you compensate for the difference in temperature, which must be tremendous where there is no atmosphere.

Dr. VON BRAUN. Well, it actually is a little more complicated than I can present here. But to put it in very simple terms, when you expose a black surface to the sun, it heats up. When you expose a white surface to the sun, it will reflect the sunlight. So if you have a sphere, a spherical body, which you paint black on one half and white on the other, simply by rotating it around, you can adjust any temperature you want. If you expose the entire black side to the sun, it gets very hot, because it doesn't reflect the heat. If you turn it around, the white reflects the sunlight, and the black reflects the heat that it has out into outer space, and it cools down. By just rotating it properly, you can adjust the temperature.

Mr. FULTON. In a space suit you couldn't have it so the rays could penetrate it through a transparent——

Dr. VON BRAUN. You mean in the dome?

Mr. FULTON. In the headpiece.

Dr. VON BRAUN. Yes; he will have to have his head protected, and it may be necessary to use tinted glass and glass that is properly prepared, so that it is transparent for him and yet reflects, for example, the heat waves, the infrared radiation from the sun.

Mr. FULTON. * * *

Dr. VON BRAUN. * * *

Mr. FULTON. * * *

Mr. FULTON. On this next Army shot, do you have a capability of reasonably getting within the vicinity of the moon, so that the two extra Air Force shots, that is, the payload, can be diverted to other purposes?

Dr. VON BRAUN. Sir, the main objective of our experimentation is still the exploration of the radiation belt around the earth. Our last firing in this respect, although it was a failure as far as reaching the moon, was very successful because it went even twice through that area and supplied us with very valuable data. We are actually after this objective again. Hitting the moon or getting close to the moon is only the secondary objective. The importance lies mainly in the psychological effects.

Mr. FULTON. Did you have infrared equipment aboard the last rocket?

Dr. VON BRAUN. Yes, sir.

Mr. FULTON. What were the results of that as regards military security? Did it perform well? On the infrared equipment, was our tracking—were we able to monitor it so we could tell how it worked?

Dr. VON BRAUN. As you know, on the last firing we were not successful simply because we did not get close enough to the moon to even use it.

Mr. FULTON. Finally, and may I say this, on your chart, I believe that when the missile approaches Mars, it moves to begin with, in a parabola because there is no forward or retroforce, but when there is a force applied that is either forward or retro, then it moves in a hyperbola. So when you move into the gravitational force of Mars, it would be a parabola?

Dr. VON BRAUN. If there is no forward force, that is right.

Mr. FULTON. So there your chart was wrong?

Dr. VON BRAUN. In this case it would be a hyperbola. It would be a parabola if there were not that initial force.

Mr. FULTON. Thank you.

The CHAIRMAN. Mr. Miller.

Mr. MILLER. Doctor, what is the Army's further ability to participate in space exploration, still carrying on its present program with its missiles?

Dr. VON BRAUN. Sir, we have a great number of assignments, both from ARPA and NASA, in the space area, very challenging assignments, and we are doing our best to meet them.

Mr. MILLER. Do you have the capability of meeting them?

Dr. VON BRAUN. Yes; and we have the assignments, too.

If you want me to be specific, I can enumerate these projects that we are conducting.

For ARPA, our most important mission is the development of 1½ million pound-thrust booster, using a cluster of existing rocket engines. These are improved Jupiter engines. This booster is designed to be the biggest booster that would be available for the years to come. * * * Its main objective for the time being is to serve as a carrier vehicle for a military 24-hour communications satellite, along the lines of one of my early charts.

Mr. MILLER. Well, those communications satellites I should think would be one of the most important, high-priority pieces in this field, because from them we can get the information to go into it further. Isn't that correct?

Dr. VON BRAUN. Yes, sir; that is correct.

ARPA has given us this project with a high priority, but I think we could speed up this operation if more funds could be made available, and ARPA is very well aware of this and has actually requested supplementary funds and would like to give us more funds if they, themselves, could lay their hands on more money.

Mr. FULTON. How much money do you want?

Mr. MILLER. Do you feel, Doctor, that this is the all-important project, or would you give it the highest type of priority?

Dr. VON BRAUN. Sir, I would, because I think all other projects that either we or the Air Force are pursuing are essentially utilizing existing ballistic missiles for space missions. All other space missiles are fallout at the moment of our military missile program. All this experimentation is necessary and valuable, but it is all based on using existing military missiles modified for space flight.

However, this is the first second-generation space vehicle designed for this purpose.

Mr. MILLER. Then if we are going to make real progress in this field and to stay ahead in the field once we catch up, this particular project of getting up these fixed satellites——

Dr. VON BRAUN. You can look at it this way—

Mr. MILLER (continuing). Is all-important?

Dr. VON BRAUN. * * *

Mr. MILLER. Now, the money is just one of the elements that enter into this thing, as far as I can sense it, because you can do just so much so fast. You can't buy information.

Dr. VON BRAUN. That is correct.

Mr. MILLER. There is no place you can go in and buy it. But you need it. To shove this particular project to the ultimate, you would need more money?

Dr. VON BRAUN. Yes, sir. Specifically, I think we are not confronted with any fundamental barriers in this project, barriers of knowledge, where we have to wait for breakthroughs. This is a very straightforward engineering project. Right now it is funded at a rockbottom minimum amount. We are doing our best to do it with this amount of money, but the handicap is that we have to assign most of the hardware we buy for the money we have for flight testing and too little remains for good ground testing jobs.

It has been our experience and everybody else's experience in this field that you can buy assurance by putting more hardware aside, components aside, in the early development stage, and subject that to very thorough ground testing so that you have highly reliable and well-proven components by the time you go into the early flight testing phase.

Our disadvantage right now is that practically all of the hardware we buy, with very little exception, must be assigned to flying hardware already, because we have promised we are going to meet a schedule, and there is too little money to buy enough, and so we have to take tremendous risks.

Mr. FULTON. How much more money do you want, with the gentleman's permission, for next year? How much is it?

Dr. VON BRAUN. Well, specifically, we have requested $40 million additional appropriation for fiscal year 1959 for this project, and $100 million additional in fiscal 1960.

Mr. FULTON. Well, you have one vote here.

Mr. MILLER. Mr. Chairman.

The CHAIRMAN. Let me say to the committee that my office just called to tell me they are getting ready to vote on a question of limiting the draft to 2 years instead of 4 years, so I am afraid that we are going to be called at any moment now.

Now, in order to get around to some of the members of the committee, the Chair is going to suggest that we limit our questions to one or two questions, so we can get around to them.

I promised to recognize Mr. Hall.

I might say I can't see them down there either, the way we are set up in there. I can't see who wants to be recognized.

Mr. MILLER. May I say in closing that I thank the doctor for what he has brought forth, and I think that is the most important testimony that we have had in this whole thing. It is concrete, and I am very happy to have it.

The CHAIRMAN. He is a great American.

Mr. HALL. Doctor, I am David Hall, of North Carolina.* * *

Dr. VON BRAUN. * * *

Mr. HALL. * * *

Dr. VON BRAUN. * * *

Mr. HALL. Thank you, sir.

The CHAIRMAN. May I ask you a question? I haven't asked any questions. * * *

Dr. VON BRAUN. * * *

The CHAIRMAN. * * *

Dr. VON BRAUN. * * *
The CHAIRMAN. * * *
Dr. VON BRAUN. That is correct.
The CHAIRMAN. Perhaps longer?
Dr. VON BRAUN. Yes.
The CHAIRMAN. * * *
Dr. VON BRAUN. * * *
The CHAIRMAN. * * *
Dr. VON BRAUN. * * *
The CHAIRMAN. Mr. Anfuso.
Mr. ANFUSO. Dr. von Braun, I too want to congratulate you for the excellent service you are giving to our country. * * *
Dr. VON BRAUN. Yes, sir.
Mr. ANFUSO. * * *
Dr. VON BRAUN. * * *
Mr. ANFUSO. Would you give us that picture, please.
Dr. VON BRAUN. * * *
Mr. ANFUSO. * * *
Dr. VON BRAUN. * * *
Mr. ANFUSO. Some people have said that we have lost the balance of power. I wanted your opinion on that, your frank opinion.
Dr. VON BRAUN. I just do not know. I would have to have more facts.
Mr. ANFUSO. Thank you.
Mr. SISK. Mr. Chairman.
The CHAIRMAN. All right, Mr. Sisk.
Mr. SISK. Just one question, Dr. von Braun. In view of the requests for work at present on hand by your team at Redstone, do you feel that your group is being challenged and that you have a sufficient amount of work allotted to you to use your skills and the skills of the people with you to its most effective capability at the present time?
Dr. VON BRAUN. Yes, sir. Our situation is such that the total number of assignments that we have is really enough to keep us busy. On the other hand, most of the programs that we have are a little bit undernourished, so we could use more funds to do a more effective job on all of these projects, so we actually need not more work but more money.
Mr. SISK. But the objectives that you have now outlined in front of you, on behalf of NASA, and ARPA and other groups are sufficient to test to the fullest your skills and ability and scientific know-how and all you need is a little additional money here and there to facilitate and expedite the program.
Dr. VON BRAUN. Absolutely. * * *.
The CHAIRMAN. Mr. Hechler.
Mr. HECHLER. * * *.
Dr. VON BRAUN. Sir, I personally advocate a well-planned long-range space program with a little more emphasis on the word "program" and a little less emphasis on the word "crash." I think the reason that we have to crash is very often that we have no program.
Mr. HECHLER. * * *.
Dr. VON BRAUN. Sir, there are certain interim steps that must be clarified first before we feel we are ready to do this. I think in an

orderly space program the first landing on the moon should be completed after these interim steps have been completed, so it would be a logical step in the entire ladder of effort.

Mr. HECHLER. I understand. Thank you.

The CHAIRMAN. Do you have a question, sir? Mr. King.

Mr. KING. Dr. von Braun, there was a time a few years ago when it was hard to pick up a newspaper without reading an account of flying saucers. Obviously most of those cases were hallucinations and we discounted them completely, but there were a few that seemed amazingly well authenticated and documented. Do you have any opinion on that phenomenon?

Dr. VON BRAUN. Sir, I have never seen one myself but I had the opportunity to talk to an Air Force officer who was assigned to that project and who would show up every time a flying saucer had been reported and he told me that his experience was that 98 percent of all these reports could be accounted for by something. Either there was a high-flying airplane or a runaway balloon, or it was Venus, or something. There were many cases on record that made the headlines that turned out to be just plain hoaxes, where a few people got together and said we will all tell the newspapers the same story, and it took the Air Force a while to find out this whole thing was a conspiracy of a couple of fellows who tried to put a hoax across. There is about 2 percent unaccounted for, but he said after a long time in this business—the name of this officer was Colonel Sterling, he worked out of Wright Field. His personal conclusion was while he still felt they should go ahead and pursue all of these reports because you can never tell and the public demands it, and so forth, that he was not convinced that there is any evidence of extraterrestrial bodies getting in our atmosphere.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. Doctor, did I understand in answer to the questions posed by the gentleman from California, Mr. Miller, that you place highest priority to the three satellites placed 120 degrees apart at 22,000 miles in orbit?

Dr. VON BRAUN. That is correct, our large booster is part of that project.

Mr. DADDARIO. * * *

Now would that not be a proper assumption?

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

Mr. DADDARIO. * * *

Dr. VON BRAUN. * * *

The CHAIRMAN. I do not want to interrupt here, but they are beginning to vote on amendments. We have no authority to sit except during general debate and I want to work with the leadership there so as not to be in session while they are voting on amendments, so if there is no objection, I think we had better adjourn. Before we do it, I want to read into the record this article taken from the local press which should be of interest to everybody in this committee:

Russia's Sputnik III will be visible here tonight if the skies are clear. The 11.8-foot, 3,000-pound satellite will pass over the Washington area at 6:48 p.m. according to the Vanguard Computing Center.

I recommend that everybody take a look at it if it is clear.

Mr. FULTON. To help Dr. von Braun, could we ask him to put into the record the total overall money he would like to go ahead with his programs for the remainder of 1959 and then for 1960, and then break it down by program, and could you also put in the record for me how you are going to make your satellites go in a circle rather than an ellipse according to Kepler's second law?

Dr. VON BRAUN. Thank you.

The CHAIRMAN. If the doctor will do it, we will be glad to have it in the record. Thank you, Doctor.

(The information referred to is as follows:)

The additional funds requested for fiscal year 1959 have been supplied since the time of the hearing.

In fiscal year 1960 an additional amount of $96 million for the Saturn program could be utilized to assure greater reliability and a better vehicle. This $96 million would be used as follows:

For details work and procurement of hardware for the upper stages of the booster, $20 million.

For engineering work on potential payloads, $9 million.

For concentrated engineering effort on all elements of the booster and the procurement of hardware for component testing in light, $48 million.

For expansion of Army Ballistic Agency test and fabrication facilities and equipment, $11 million.

For the launch facility at the Atlantic Missile Range, $7 million.

Mr. FULTON. I would like to join with general counsel of the select committee, George Feldman, Dr. Charles Sheldon of our staff, as well as Mr. Philip Yeoger, and Eilene Galloway, when we compliment you highly on your appearance and address in Amsterdam, Holland, on Saturday, August 30, 1958, when you explained to the 26 nations of the International Astronautical Federation the results obtained from the three Explorer satellite programs of the United States. We were proud to be there and hear you and to see the fine reception which every nation gave.

As a matter of fact, the eyes of the world are upon you whether you are in Alabama, Texas, or Amsterdam at the time.

Dr. VON BRAUN. Thank you.

(Whereupon, at 4:11 p.m., the committee was recessed.)