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MANNED SPACE FLIGHT U.S.-SOVIET RENDEZVOUS AND DOCKING

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HEARING BEFORE THE SUBCOMMITTEE ON MANNED SPACE FLIGHT OF THE COMMITTEE ON SCIENCE AND ASTRONAUTICS U.S. HOUSE OF REPRESENTATIVES NINETY-SECOND CONGRESS

SECOND SESSION

MAY 31, 1972

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May 31, 1972:

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MANNED SPACE FLIGHT U.S.-SOVIET RENDEZVOUS AND DOCKING

WEDNESDAY, MAY 31, 1972

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON MANNED SPACE FLIGHT,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:30 a.m., in room 2318, Rayburn House Office Building, Hon. Olin E. Teague (subcommittee chairman) presiding.

Mr. TEAGUE. The committee will come to order.

The committee is meeting this morning to hear Mr. Dale D. Myers, Associate Administrator for Manned Space Flight, discuss the joint U.S. and Soviet Union rendezvous and docking mission of 1975.

Would you introduce the gentlemen with you, Mr. Myers?

STATEMENT OF DALE D. MYERS, ASSOCIATE ADMINISTRATOR, OFFICE OF MANNED SPACE FLIGHT, NASA; ACCOMPANIED BY ARNOLD W. FRUTKIN, ASSISTANT ADMINISTRATOR, OFFICE OF INTERNATIONAL AFFAIRS, AND GLYNN LUNNEY, SPECIAL ASSISTANT TO THE MANAGER, APOLLO SPACECRAFT PROGRAM

Mr. MYERS. Mr. Chairman, it's a delight to be here today and to have this opportunity to describe to you the docking experiment that we are going to conduct in 1975. I have with me Mr. Arnold W. Frutkin, Assistant Administrator for International Affairs and Dr. Glynn Lunney, who is the project manager for the joint mission.

Dr. Glynn Lunney is at the Manned Spacecraft Center and has been involved in all of the technical meetings that we have had with the Soviet Union concerning this program since its beginning back in 1970.

I want to take this opportunity to describe briefly the configuration. Then I would like to turn the meeting over to Dr. Lunney to further describe the details of our activities as they have developed with the Soviet Union and the definition of the program that we are dealing with.

I would like to show a couple of slides that describe, first, what we are not doing and then, second, what we are doing. There was a period of time during our discussions with the Soviet Union about the possibility of an experimental test with the Salyut Space Station. That

period of time began in June of 1971 after the Russians had launched their first Salyut Space Station. They began to talk about the possibility of an experiment to prove out the capability of a common docking system.

This is a picture of a Soyuz spacecraft. At the lower left-hand side is a Salyut Space Station and then finally a docking module and a command and service module.

Mr. TEAGUE. Is this the type of station they have up there now?

Mr. MYERS. This is the type of station that was launched in April of 1971. It is the one that was up there for quite a while. The first mission was to dock, enter the Salyut and operate with it for a while. The second mission was one in which three men stayed aboard the Salyut for 24 days in a series of experiments much like we will have in our Skylab program. It was that mission with Soyuz 11 where, after docking and reentry into the atmosphere, they had difficulty with their hatch and lost their three cosmonauts. They have a continuing program with Salyut, although they have not launched a second Salyut. We are sure there are a continuing series of space stations they will have of this nature.

Mr. WYDLER. What hatch didn't work?

Mr. MYERS. It was a hatch in the Soyuz spacecraft itself.

Mr. WYDLER. Where would that be located?

Dr. LUNNEY. On the lower part of that drawing on the left-hand side, with two solar panels that look like wings, is this particular spacecraft without those wings. This is the Soyuz they call the transport ship to go up to the station. The reentry portion of this vehicle is actually this small bullet-shaped section in the middle.

Here is the Soyuz system. This is the equivalent of our service module back to about here [indicating]. The piece right here is their reentry module, what we would call a command module. Then the next piece is a living module for them. Their command module is so small they have an additional 7½-foot-diameter ball at the end of the system that they live in while they are in orbit.

When they dock to the Salyut, they move on beyond the living module on into the Salyut. They lived in there for 24 days during the flight that they had with the Salyut. Beyond that is now what we will be talking about today, the docking module and command and service module.

It was this hatch between the living module and the command module that failed during reentry of the Soyuz 11.

Mr. WYDLER. Is there going to be any thought of that in this coming experiment?

Mr. MYERS. It was associated with the coming experiment. We will talk a little later about the safety aspects of the system, Congressman Wydler. It would not in any way be associated with our personnel in such a flight. It's very clear that they have had a complete in-depth analysis of that seal, and I am sure they have fixed that.

Mr. WYDLER. If I understand the story, what is going to happen now is that that particular hatch, you are talking about is the hatch within their own vehicle?

Mr. MYERS. That is right.

Mr. WYDLER. That isn't the one they are going to hook up to ours?

Mr. MYERS. No, it is not.

In early April, we had a meeting with the Soviet Union and further discussions were held concerning this experimental docking mission. As you know, the original intent of our discussions with the Russians was to develop a compatible docking system for future spacecraft that would give us the opportunity to enhance rescue capabilities between the two nations and that could eventually lead to cooperative programs between ourselves and the Soviet Union.

The developments that occurred in June 1971, were to study the possibility of an experimental mission earlier than the time period when new systems like the shuttle would come into being. That is when we first talked about the Soyuz-Salyut docking with a command module.

In the April 1972 meeting, the Soviet Union described studies that they had completed and their decision that from an economic and technical standpoint they would be better off having the test program done with the Soyuz docking with the CSM. So the mission, as now envisioned between the two countries and as agreed to in the agreements May 24 with the President and the Soviet Union, is to use the Soyuz spacecraft.

Again this lower portion, including their living module, is a new docking module designed and built by the United States and one of our existing command and service modules. The interface, where we have the common docking equipment that would be compatible between all spacecraft in the future, would be right at this point.

Glynn Lunney will be describing this in his briefing today.

I wanted to point out because we have discussed earlier with the committee the idea of the possible experimental docking with the Salyut Space Station. The Salyut is no longer a part of this docking mission. It will be a flight of a Soyuz spacecraft and a command and service module docking.

I would like to introduce Dr. Lunney, who is the Project Manager at MSC and have him describe further the mission that we plan here.

Dr. LUNNEY. I have some charts to show you here today on the Apollo-Soyuz mission.

First I would like to say I am pleased to be here and have this opportunity to talk with you about it and, as we go through it, any questions that you want elaborated on, I can do so with the charts and perhaps some of the models we have.

APOLLO/SOYUZ TEST PROJECT

- CHRONOLOGY OF MAJOR EVENTS
- CONTEXT OF COOPERATIVE ACTIVITIES
- PRELIMINARY MISSION DESCRIPTION
- DESCRIPTION OF VARIOUS HARDWARE ELEMENTS
- MANAGEMENT OF ENGINEERING PHASE
- MANAGEMENT OF REAL-TIME OPERATION

FIGURE 1

(Figure 1) This will give you an idea of what I intend to cover. Dale Myers has already touched upon a number of things associated with the chronology of the major events. I will briefly go through those so you can see the history of the last two or so years while these discussions have been going on.

I would like to reemphasize the context we are doing this in. That is in the terms of rendezvous and docking. I have some charts which will give you an idea of the preliminary mission description and a description of the various hardware elements or spacecraft elements which are associated with this mission.

Lastly, I would like to touch upon some of the discussions we have had with the Soviet Union relative to the management of this project, both in terms of the phase prior to the mission—the engineering phase—and in terms of the real time operation.

CHRONOLOGY OF MAJOR EVENTS

COMPATIBLE RENDEZVOUS AND DOCKING

- APRIL 1970 - DR. PAINE INFORMALLY DISCUSSED COOPERATION IN AREA OF ASTRONAUT SAFETY, INCLUDING COMPATIBLE DOCKING UNITS
- JULY 1970 - DR. PAINE SUGGESTED THIS POSSIBILITY BE CONSIDERED IN A MEETING
- OCTOBER 26 - 28, 1970 - FIRST MEETING IN MOSCOW BETWEEN NASA AND ACADEMY OF SCIENCE, RESULTED IN
 AGREEMENT TO DESIGN COMPATIBLE RENDEZVOUS AND DOCKING SYSTEMS FOR FUTURE MANNED VEHICLES
 AGREEMENT ON PROCEDURES AND SCHEDULE OF EXCHANGES
- JANUARY 1971 - DR. LOW PRIVATELY SUGGESTED TO ACADEMY OF SCIENCE PRESIDENT KELDYSH THAT PRESENT SPACECRAFT APOLLO AND SOYUZ BE CONSIDERED FOR A JOINT MISSION

FIGURE 2

(Fig. 2) For chronology, back in April of 1970, Dr. Paine informally discussed the possibility of cooperation in the area of astronaut safety, including the possibility of a rendezvous and docking mission with the Soviet representative, Academician Blagonravov, when he was in this country. Dr. Paine suggested in a letter to President Keldysh, President of the Academy of the Sciences of the U.S.S.R., the possibilities to be considered and explored in a subsequent meeting.

The first meeting on the subject was held in October 1970, at which time about five of us went over and discussed this subject, reaching conclusions that we would work on the design and compatible rendezvous and docking systems for future vehicles.

I should at this point emphasize that in October of 1970 we were talking about future vehicles, those still in the design stage. In our program that would be, of course, the shuttle and beyond, as opposed to existing Apollo spacecraft.

We also agreed on procedures and a schedule of exchanges to update our experience in rendezvous and docking and what we foresaw in the future as requirements for our own programs.

In January of 1971, after that first meeting, Dr. George Low, who was then Acting Administrator of NASA, I believe, privately suggested to President Keldysh of the Academy of Sciences that we consider the possibility of using an Apollo spacecraft and a Soyuz spacecraft for a joint mission. At this time the discussions had not proceeded to the point of considering using the new docking system. There was not a real favorable response to this proposal at this time.

CHRONOLOGY OF MAJOR EVENTS (CONT)

JUNE 21 - 25, 1971	- SECOND MEETING IN HOUSTON RESULTED IN AGREEMENT TO STUDY POSSIBLE TEST MISSIONS BETWEEN APOLLO AND SALYUT, AND SOYUZ AND SKYLAB WITH EMPHASIS ON APOLLO AND SALYUT AGREEMENT ON MANY TECHNICAL SUBJECTS REQUIRED FOR COMPATIBILITY OF FUTURE VEHICLES FOR RENDEZVOUS AND DOCKING
NOVEMBER - DECEMBER 1971	THIRD MEETING IN MOSCOW RESULTED IN AGREEMENT ON TECHNICAL FEASIBILITY OF APOLLO/ SALYUT TEST MISSION AGREEMENT TO STUDY FURTHER TECHNICAL AND ECONOMIC FACTORS INVOLVED IN JOINT TEST MISSION FURTHER AGREEMENT ON TECHNICAL SUBJECTS REQUIRED FOR COMPATIBILITY OF FUTURE VEHICLES

FIGURE 3

(Fig. 3) Perhaps the reason for this became clear in June at the second meeting which was held in Houston. At that time, on the second item up there, we proceeded to make considerable progress agreeing on a lot of the technical subjects which would have to be made compatible for both rendezvous systems—by that I mean the radio guidance systems, the lights, docking targets, et cetera—and the docking mechanism itself, which is essentially a mechanical device.

With those agreements the subject of a possible test mission was first brought up and discussed in a preliminary fashion. At that time we did not discuss any details of how such a mission would be conducted, but we agreed that both sides would study it. We did agree that the possibilities were Apollo and Salyut, and a Soyuz and Skylab with emphasis on Apollo and Salyut. The emphasis was clearly to be placed upon the Apollo and Salyut at this time because both vehicles were then in a flight stage. As a matter of fact, Salyut was flying at the time of the meeting in June of 1971.

We made clear that we would have a very difficult time making any modifications on the Skylab, which is planned to be flown next year, to accommodate such a mission. It was agreed that it would be looked at. In between these meetings there were exchanges of technical papers.

The third meeting in Moscow resulted in a fairly detailed discussion of how one would conduct such a mission. We concluded that it was technically feasible to perform an Apollo-Salyut test mission. A variety of things associated with that mission had been laid out in preliminary fashion. For example, the mission profile, the idea of a docking module to adapt the environments between the two ships, a preliminary idea on how to design a docking mechanism, et cetera.

We did agree also, and probably very importantly as a result of the change from Salyut to Soyuz, that both countries had to continue to study not only the technical but the economic factors involved in conducting such a joint test mission.

We also made further progress on many technical subjects required for compatibility for the future vehicles.

CHRONOLOGY OF MAJOR EVENTS (CONT)

APRIL 4 - 6, 1972 - FOURTH MEETING IN MOSCOW RESULTED IN
 CONFIRMATION OF DESIRABILITY OF JOINT TEST
 MISSION
 AGREEMENT TO USE APOLLO AND SOYUZ FOR SUCH A
 MISSION
 AGREEMENT TO USE U. S. DOCUMENTS DESCRIBING
 PROJECT MANAGEMENT AS BASIS FOR JOINT
 DEVELOPMENT
 AGREEMENT ON SPECIFIC PRINCIPLES EMBODIED
 IN THOSE DOCUMENTS

FIGURE 4

(Fig. 4) In April of this year, about 2 months ago, there was a fourth meeting in Moscow where we discussed primarily two things. One of them was what we had planned to discuss in going over there. That is the management aspects of such a mission. The second was a change from the Salyut to the Soyuz. At this meeting the members of the Academy of Sciences of the U.S.S.R. informed us that, in their study of the possibility of using the Salyut as part of this test mission, they had come to the conclusion that there were considerable technical and economic difficulties for them in doing such a project.

They concluded, among other things, that the redesign of the Salyut and the control system modifications that would have to be made to the Salyut in order to keep the entire stock of vehicles stabilized would have given them some technical difficulty in general and specifically in their control system.

They would have to design a second docking berth in order to accept the docking of an Apollo space system to their Salyut. Their conclusion was that the redesign, both technically and the money that would be required to finance it, made that option extremely difficult for them. They recommended that we consider the use of the Soyuz.

We went into the meeting with a background of having studied the Soyuz-Apollo mission previously, so that we had some familiarity with the technical factors that would bear on such a mission.

Also, we found that all of the objectives that we had for testing the equipment that would be associated with this mission, primarily the new compatible equipment, the docking mechanism and other equipment which I will show you in a minute, would still be the same. As a matter of fact, in essentially all respects, the mission profile was kept

as similar as possible and previous agreements were all kept intact. We could find no difficulty or unreasonable technical situations that we would get into by docking to the Soyuz rather than the Salyut.

Not that this bore heavily on us at the time, but, in a sense, it is somewhat easier to arrange the docking of two vehicles rather than to engage in a mission where we would have to arrange the rendezvous and docking of three vehicles. That was the surprise for us when we arrived in Moscow in April.

The second area, and the one which we were primarily intent on focusing on when we went there, was to discuss the management aspects of such a mission. We had, until this time, been primarily engaged in the discussion of how we would design and build the equipments to accomplish it and how we would perform such a mission.

At this point, we felt we had to go into some depth in discussing how we would manage and organize such a project and how we would communicate with each other, how we would assure each other that we were on schedule and how we would control all the different factors that went into such a mission.

In trying to accomplish this, we provided a number of documents in the continued exchange we had, which summarized how we felt such a project could be organized. It was called an organizational plan and a schedule plan. The Soviet Union members decided, and recommended, that we use those documents as a basis for further joint development. They did not have any specific objections to any of the material in those documents.

As a matter of fact, in order to assure that both sides understood each other, we extracted a number of principles for both the engineering phase and for the real-time operation of the mission. We spent perhaps a day going through those principles and enclosed those particularly in the minutes of that meeting.

CONTEXT OF COOPERATIVE ACTIVITIES

- FUTURE MANNED VEHICLES OF BOTH COUNTRIES WILL BE DESIGNED WITH COMPATIBLE EQUIPMENT FOR RENDEZVOUS AND DOCKING
- THIS COMPATIBILITY ENHANCES THE SAFETY OF ASTRONAUTS AND COSMONAUTS OF BOTH COUNTRIES IN EARTH ORBIT FLIGHT
- THIS COMPATIBILITY ALSO PERMITS THE CONSIDERATION OF PLANNED COOPERATIVE EXERCISES IN SPACE
- THE APOLLO/ SOYUZ TEST PROJECT IS AN EARLY TEST OF THE DESIGNS OF THE COMPATIBLE EQUIPMENT NECESSARY FOR RENDEZVOUS AND DOCKING
- THIS TEST MISSION WILL ALSO RESULT IN A DETAILED UNDERSTANDING AND EXPERIENCE IN THE CONDUCT OF JOINT FLIGHTS BY THE U. S. AND USSR

FIGURE 5

(Fig. 5) Before I discuss the mission, I ought to again make clear the context of the cooperative activities as we have discussed them with

the Soviets. We agreed that future manned vehicles of both countries will be designed with compatible equipment for rendezvous and docking. The compatibility that we seek enhances the safety of astronauts and cosmonauts of both countries in earth orbit flight.

Further, and as an option yet to be fully explored, this compatibility permits the consideration of planned cooperative exercises in space.

The Apollo-Soyuz test project is an early test of the designs of the compatible equipment necessary for rendezvous and docking and should be seen in that light.

Further, the test mission will result in a detailed understanding and a gaining of experience in the conduct of joint flights by both countries and in a larger sense perhaps a better understanding of how we could cooperate together in the future.

APOLLO/SOYUZ TEST PROJECT

MISSION OBJECTIVE

- PRIMARY OBJECTIVE - TO TEST THE TECHNICAL REQUIREMENTS AND SOLUTIONS FOR COMPATIBILITY OF SYSTEMS FOR DOCKING FUTURE MANNED SPACECRAFT OF THE USA AND USSR
- THIS INCLUDES
 - FLIGHT TEST OF A COMPATIBLE RENDEZVOUS SYSTEM
 - FLIGHT TEST OF A COMPATIBLE DOCKING SYSTEM
 - VERIFICATION OF PROCEDURES FOR JOINT CREW TRANSFER
 - JOINT CREW ACTIVITIES WHILE DOCKED
 - GAINING EXPERIENCE IN CONDUCTING JOINT USA/USSR FLIGHTS, INCLUDING PROVIDING AID IN FLIGHT EMERGENCIES

FIGURE 6

(Fig. 6) To discuss the mission itself, we had already agreed on objectives. Primarily, we are interested in testing the technical requirements and the solutions that we both are designing. This includes things like lights and the use of our present Apollo radio tracking system. We would include a flight test of a new compatible docking system, which I can show you with models a little later on this morning.

We would verify the procedures for transferring crews between vehicles in an airlock. In the future, rescue operations might entail the operation of an airlock to bring people from one vehicle to another. In this case, we could design and operate this airlock as we would propose to try to standardize airlocks in the future.

We would have a definition of joint activities while the two vehicles were docked. At the present time we don't have real specific identifica-

tion of experiments or scientific or technical activities that the crews could carry out together. I should characterize this by saying it's at a very early stage of thinking.

The last objective is a general one in terms of gaining experience in conducting these flights, including an understanding of how one might provide aid in emergency situations.

APOLLO/SOYUZ TEST PROJECT OVERALL SPACE VEHICLES

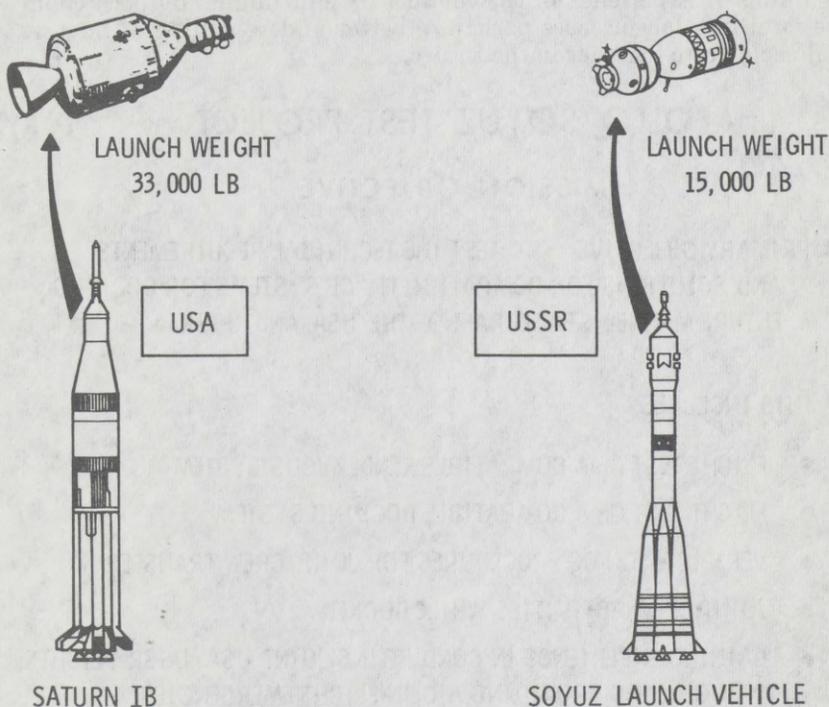


FIGURE 7

(Fig. 7) To give you an idea, the launch vehicles are approximately to scale, as are the other two vehicles. We would use a Saturn 1-B, including a command and service module and a docking module which would be extracted from the top end of the Saturn, much as we extract the lunar module in our present launch vehicle and the Soyuz spacecraft you see up there weighing about 15,000 pounds.

The one change that the Soviets have indicated to us that they would make to this vehicle is that it would not have the solar panels on it, as have some of the previous long-duration Soyuz spacecraft that they have flown.

Solar panels on the device are on the back end and look somewhat like wings. They intend to power this vehicle apparently with batteries stored in the equivalent of their service module back into the ship. Therefore, they don't see the need for the solar panels.

APOLLO/SOYUZ TEST PROJECT MISSION PROFILE

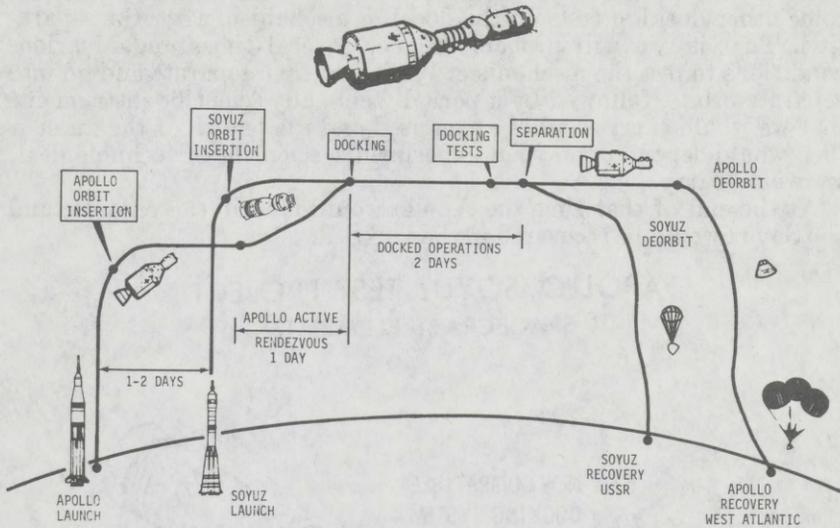


FIGURE 8

(Fig. 8) I will have to call this, at this point, a preliminary mission profile, but this is how we would see such a mission being conducted. We foresee that we would launch the Apollo first into a reasonably low-altitude earth orbit on the order of about 110 nautical miles.

The first rendezvous opportunities would exist about 17 hours after the launch of the Apollo. That might be too soon for the countdown coordination.

At this point we don't know whether the first launch opportunity that the Soviets would want to take advantage of would be in the first day or the second day. But approximately 1 to 2 days after the Apollo launch, the Soyuz would be inserted and go into a target orbit. At that time the Apollo would begin a series of maneuvers, similar in many respects to the series of maneuvers we use in the rendezvous sequence for Skylab to arrive in the vicinity of the Soyuz spacecraft, probably on the order of 1 day later.

In our programs to date we have used a relatively fast rendezvous scheme. For example, at the moon we are now docking in one revolution or 2 hours. In the Gemini earth orbit flights we rendezvous in periods of $1\frac{1}{2}$ hours up to about 6 hours. However, for the variety of conditions which we will want to cover and for the coordination necessary between the two countries, we would like to take our time with this rendezvous, which allows launching under a variety of initial conditions and to take care of any dispersions in the target orbit or in the orbit of the Apollo.

At the present we are planning to have the vehicles dock up to a period of 2 days. The exact length of the dock phase is not yet finally determined. It will depend upon more detailed definition of the time

line or the sequence of events involved when we dock both spacecraft together and what other activities the flight crews and the cosmonauts could engage in while docked.

After this period, we would separate. We will probably perform some other docking tests on the docking mechanism after the separation. That is, we will probably redock several times under various conditions to test the mechanism. We would then separate and go into separate orbits, followed by a period where any scientific instruments that we would carry would be exercised and the length of the mission then would depend upon what experiments, scientific or technological, we would carry.

At the end of that time the Apollo would land in the Atlantic and the Soyuz would be recovered in the U.S.S.R.

APOLLO/SOYUZ TEST PROJECT SPACECRAFT ELEMENTS

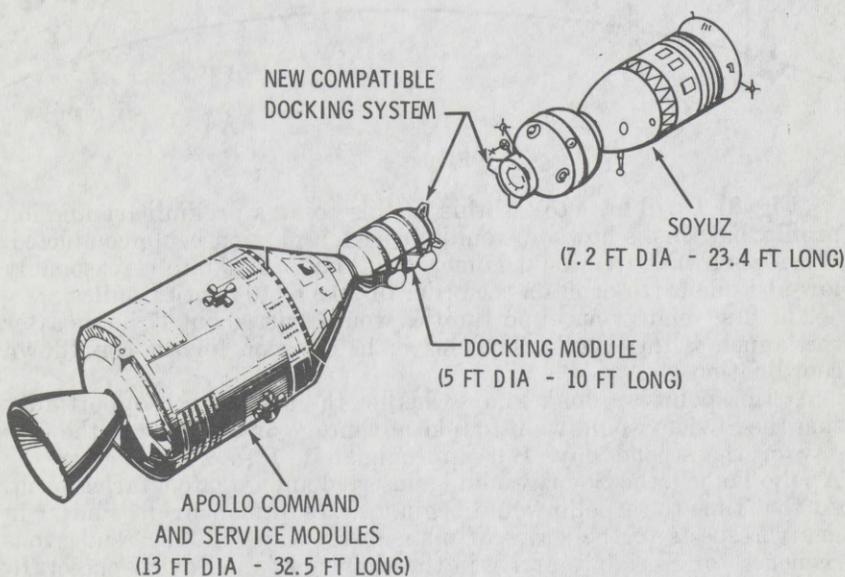


FIGURE 9

(Fig. 9) I have another version of the two vehicles you have seen a number of times. Here is the Apollo command and service module and the docking module on the front end and the Soyuz with its instruments prepared to dock.

LAUNCH CONFIGURATION FOR THE APOLLO CSM AND DOCKING MODULE

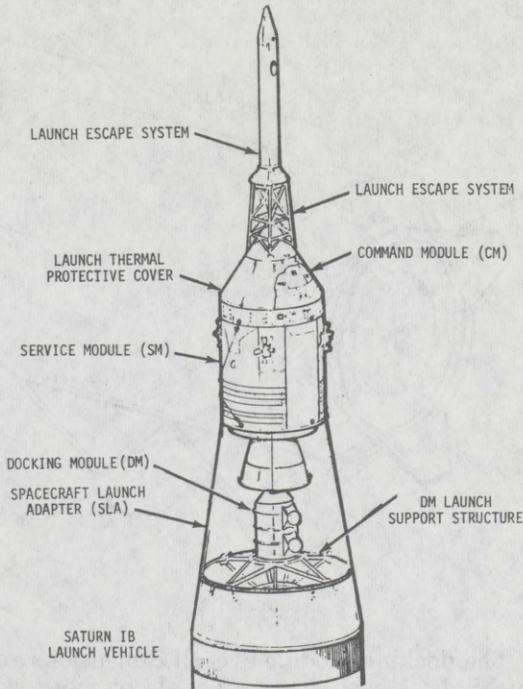


FIGURE 10

(Fig. 10) I have described how we would lift the docking module out of the top of the Saturn stage. In the launch configuration we would store the docking module inside the adaptor on top of the launch vehicle in a similar fashion to the location of the lunar module going to the moon. On the way up, of course, the tower is jettisoned after we get outside of the atmosphere. After we arrive in earth orbit these panels would be opened. The command and service module would separate and would turn around and dock with what would be, in this slide, the top end of the docking module with the current docking system that we have on the Apollo spacecraft, that is, the probe on top of the command module and the drogue system like we have in the lunar module mounted on the front end of this device. This would be the way we would launch the module and carry it in effect on the nose of the spacecraft while we are in earth orbit.

DOCKING MODULE OVERALL DIMENSIONS

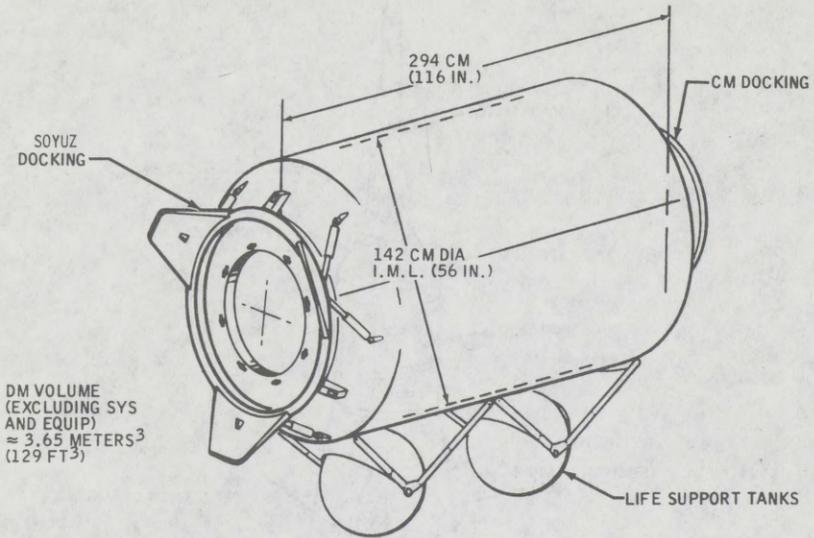


FIGURE 11

(Fig. 11.) The docking module overall dimensions and geometry is shown on this slide. I should say a couple of more words about the docking module beyond what was touched upon earlier. In the future, we intend to operate our spacecraft at one atmosphere of pressure with a mixed gas. Presently in Apollo we are operating at 5 psi, which is about one-third of an atmosphere with essentially a pure oxygen environment.

The Soviet Union is now flying vehicles which operate at one pressure with an air like composition of gas inside. That is: nitrogen and oxygen in about the same ratio that we have here on earth. Our intention in the future is also to fly that way. In the agreements we reached on future vehicles, they reflect that trend in our program.

In order to bring our men into the Soviet vehicles and to bring them back, we need some way to adjust the pressure. We looked at adjusting the pressure in the Apollo spacecraft itself, but found that the basic structure that we had built essentially depends upon operating at the normal five pounds of pressure. We would not be able to operate our existing Apollo spacecraft safely at the one atmosphere pressure and still retain the factor of safety that we would like to have in the basic structure. That is not a satisfactory technical solution to the problem.

We have conceived this device which we can close off with hatches, pressurize up to the Soviet pressure, and move our men in and bring them back. Also the docking module provides a location upon which to mount the new docking mechanism.

In the future our spacecraft will have the docking mechanism de-

scribed right here. I have a more detailed slide on that. This device would not fit anywhere on the Apollo spacecraft itself. As you probably can remember, the docking probe for the Apollo is on the nose of the command module and is actually covered during the ascent into orbit. This device that we are testing is far too large to fit in that area. The docking module also serves as a structural bed upon which to mount this docking mechanism. The overall mechanism is simply bolted to the docking device.

The third reason why we have selected a docking module approach, and to my mind one of the key reasons, rests on this fact. When our astronauts are in the Soviet vehicle, they will have the nitrogen of the air in the Soyuz in their bodies. When we take people from the high pressure with nitrogen in their blood stream back to the low pressure of the command module, we have to be very careful and provide for prebreathing in order to cleanse the nitrogen out of the blood stream. If this is not done, one runs the risk of having bends occur in the people which you have exposed to that change of pressure.

In order to do this, the docking module is designed to allow about 2 hours of prebreathing on pure oxygen at the higher pressures with the hatches closed before one reduces the pressure and brings it down to a pressure satisfactory to the command module. In this way we have a system which permits us to exit from the Soyuz, close the hatch, and stabilize our astronauts in essentially an American vehicle while we are waiting for the prebreathing to take place, the denitrogenization of the blood to take place before we bring the pressure down to go into the command module. In this respect we then have a very important design escape route if we have a problem in the Soyuz which requires our men to exit the Soyuz in what we would call a hurry. If they have to get out of the Soyuz in a hurry because of some kind of problem, we can put them in a docking module, keep it at the higher pressure so that we do not run the risk of our men getting the bends, and separate with the docking mechanisms if that would be required in emergency conditions.

It's for those kinds of reasons that we see that the docking module provides a very integral part of this mission and also provides us with a safety feature in the design of the entire mission, which is much to our advantage and will help us a great deal in planning the mission and in planning for any contingencies which might arise which we will have to consider in preflight.

Mr. WYDLER. You make it sound like you had a lot of good reasons why we are going to have a docking module. What was the alternative?

Dr. LUNNEY. There are a number of alternatives. One is that the transfer could be made outside the vehicles. In other words, we could have sent our astronauts outside, go out the command module hatch, climb across and go to the Soyuz. Once they do that, they would have to again spend about two hours or so prebreathing in the Soyuz before they could come back out. In all the manned programs we have tried to avoid the need to go outside for any activity. We would also be in a posture where it would take a good deal of time, preparation and coordination in order to come back to the Apollo.

One of the other reasons I am spending some amount of time on it is that in a number of discussions the question has arisen as to why we have the device and what other solutions might be available. This one is available, but for reasons of wanting to keep the men inside and for reasons of wanting to be able to get our men back quickly if required and therefore enhance the safety of the flight, we wanted to be able to design and operate this docking module in the fashion described here.

Mr. WYDLER. Then the alternative was to go outside?

Dr. LUNNEY. Yes, sir.

Mr. TEAGUE. Who is in command? Suppose you have to do something quickly and you have to make a decision quickly. Who is in command? You can't have two bosses when you get into a situation like that.

Dr. LUNNEY. So far we have agreed that each country would have control of its own spacecraft and its own crew. We have also agreed that we would approach the flight in the same way that we planned for and approached the flights in our own programs to date. That is, we would plan a certain nominal time line and we would plan what action should be taken for certain contingencies or failures or malfunctions in the other vehicle.

We have agreed that when there are visitors in one's vehicle—for example, when there would be a Soviet visitor in the Apollo—that the United States would have the responsibility for determining what course of action was proper for any given situation that we might have in the Apollo. We would then pass on the necessary instructions to the Soviet cosmonaut, either telling him in the worst case perhaps, to go on back to his ship or telling him that we had a problem that would take 15 minutes to fix and we would be in a standby condition.

Similarly we have agreed that when our men are in the Soyuz, for any malfunction or deviation or whatever that might occur in the Soyuz, that the Soviet Control Center—or their spacecraft commander when they are out of sight of the Soviet Control Center—would have the responsibility for instructing our astronauts as to what the proper course of action was.

We would try to agree ahead of time what all these possible courses of action might be and also understand what failures in the other country's equipment would cause him to want to execute any of those courses of action.

Additionally, there will probably be some problems where it is not immediately obvious that the problem is in one ship or the other. Hopefully these will be few. For example, a control system would be causing a motion. We will try to arrange, both by how we design the mission and by special attention to those kinds of problems, how we could quickly clarify where the problem might lie so that the respective control center and/or commander could take the proper action.

Mr. TEAGUE. What about communications? Do you envision having to use a lot of interpreters? Or are you going to have all the astronauts studying Russian?

Dr. LUNNEY. There are two answers to that question. One, I think we will have a lot of use for interpreters. At the Manned Spacecraft Center we are already starting to enlist a number of our engineers who are able to speak the language. As a matter of fact, on the last trip that some of our men went on to Moscow, they took one of our engineers with them. He provided that service for them.

Second, as a minimum, we think that the flight crews will have to be trained in each other's language well enough to understand that a course of action is required. They will have to understand that the commander is telling them to take a certain course of action, and they will have to be trained well enough to proceed to do that. As a goal, we would like to find ourselves in the position where all of the flight crews understand both languages very well, very fluently. But as a minimum, they will have to be able to understand what course of action should be taken.

Mr. WYDLER. Do we have any astronauts who speak Russian?

Dr. LUNNEY. Not currently. There are a number of them studying it and trying to learn it.

Mr. WYDLER. Are there going to be Americans in the control center in the Soviet Union during this docking procedure?

Dr. LUNNEY. In April we discussed exactly that point with our opposite numbers in the Soviet Union. We agreed that the objective is to provide consistent and thorough understanding to the other country's control center as to what is going on.

For example, if we have problems during flight where it may seem like a large problem, but it really isn't a problem at all, we have to find a technique for communicating that to the other side. Conversely, they would have to find a way to interpret certain situations on their side to us.

We have not decided on what is the best way to satisfy that objective. One possibility is to locate people in each other's Control Center. There are other possibilities like, for example, dedicating a man in each control center who is full-time and whose only task would be to keep the other country informed. That is a technical man, like, for example, one of our flight directors whose sole task would be to inform the other side what is going on, what the ramifications were, et cetera.

The spirit so far has been—yes, we must find a way to satisfy the objective of thorough and well understood communications. Precisely how we would do that, we haven't decided yet. I don't feel that we on this side know yet what would be the best way. That will probably take some time and some development. We have agreed that that must be done somehow.

APOLLO/SOYUZ TEST PROJECT

MAJOR ITEMS OF COMPATIBILITY

- RADIO FREQUENCY VOICE COMMUNICATION SYSTEMS
- RADIO GUIDANCE SYSTEMS
- DOCKING ALINEMENT TARGETS
- DOCKING MECHANISMS
- METHODS FOR ADAPTING ATMOSPHERIC PRESSURES

FIGURE 12

(Fig. 12) These are some of the elements where we have been working for compatibility. We want to have a radio system that will allow our astronauts and cosmonauts to talk with each other. Also this will allow some conversation to the other country's control center.

Mr. WYDLER. Excuse me. Could I go back just a minute. I want to make sure I understand your previous testimony. Did you state that the United States is now going to change the atmospheric conditions in the future manned space flight missions? Did I understand you to say that? If so, when is that going to happen? That is something I was interested in.

Mr. MYERS. Prior to these discussions with the Soviet Union concerning this operation, we had made the decision to go to 15 p.s.i. pressure in the Shuttle. That would be for future activities in the Shuttle. In such things as our sortie module that will be carried in the Shuttle, we would be using a full atmosphere.

Mr. WYDLER. So the Soviet atmosphere and our own would be compatible?

Mr. MYERS. Yes, in future programs they would be compatible.

Mr. WYDLER. You also mentioned the safety factor. We couldn't change it in this case because it would endanger the operation of the Apollo module. Why? In what way would it endanger it?

Dr. LUNNEY. The Apollo command module is designed to operate at 5 pounds pressure. It can go up higher than that. We always like

to have a factor of safety of at least 1.5 above the maximum operating pressure that we expect to operate in flight.

Mr. WYDLER. I don't understand what danger is that you are protecting.

Dr. LUNNEY. It will rupture.

Mr. MYERS. The rupture of the structure of the command module itself, if you go very much higher than 15 p.s.i.

Dr. LUNNEY. On these items I mentioned, on the subject of radio guidance systems, we are not for this mission going to design a new radio guidance system. Our discussions have not yet arrived at the point where the long-term radio guidance systems for future vehicles are defined well enough to try to do that. We would propose to use the present Apollo ranging system that we have on the command and service module today. As for the docking alignment targets, I will show you a sketch in a minute as to a system of allowing the astronauts to view the target as they approach so that the docking mechanisms can be properly gaged so they will hit at the right angle with the smallest amount of misdistance and then close in. We have to be mechanically compatible in order to bring the two vehicles together and seal them so we have an airtight seal. On the methods for adapting the atmospheric pressures, as I mentioned earlier, future vehicles will have air locks of some type. The docking module that we are designing is intended to be compatible with the way in which we would tend to operate air locks in the future, as we have outlined for our program and as we have discussed with the Soviets.

NEW COMPATIBLE DOCKING SYSTEM

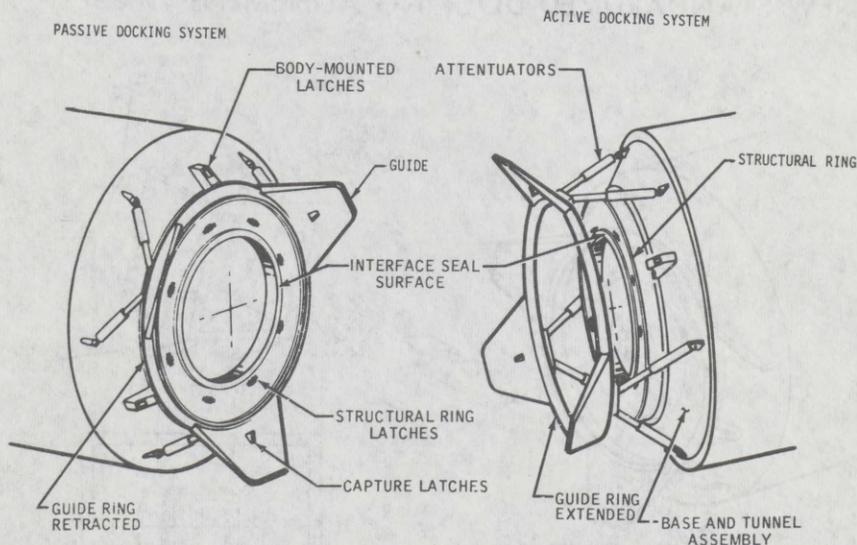


FIGURE 13

(Fig. 13.) To give you a picture of the docking mechanism, some time ago in our studies in this country we saw the advantage of going to a

system which would be externally mounted. Presently we have a probe and drogue system inside the tunnel area. In other words, our present Apollo has a device which is right inside the tunnel area so that the astronauts have to remove it prior to being able to transfer through here. Also, on one side there is a probe and on the other side there is a drogue, a female-type device which will accept that probe. In the future we would like to design docking mechanisms such that we don't have to have a male and female part in order to accomplish the docking, but all vehicles would be equipped with this type of docking system which, as you can see, is essentially identical to that one, where you just slide over a little bit and bring the two devices together.

The latches for latching the spacecraft together are mounted in the ring. The rings are brought together once we engage out here on small latches; the active system is retracted and both rings are brought in contact with each other and hooks reach across, latch to the hooks on the other side, and then are brought down to provide the pressure seal and the structural integrity of the docking mechanism itself.

Mr. WYDLER. Has anybody ever built that kind of a system?

Dr. LUNNEY. We have built models of it. As a matter of fact, early in Apollo we considered this as a design possibility. But because of volume limitations on the front end of the Apollo, we did go with the probe and drogue system that we now use on Apollo. The advantages of this type of system have been known for some time. Prior to our discussions with the Soviet Union, we had planned to produce and use such a system on the shuttle as a docking mechanism.

NEW STANDARDIZED DOCKING ALINEMENT TARGET

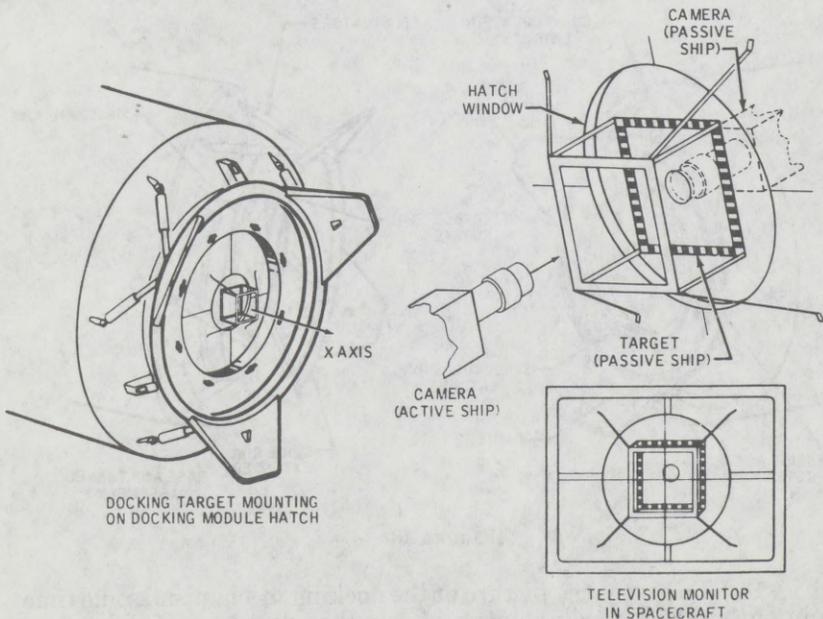


FIGURE 14

This (fig. 14) is an example of the docking aid device that I was referring to earlier. As the two vehicles are brought close together, the astronauts need some form of reference in order to be sure that the docking mechanisms are lined up. We are planning to use a target over here on the Soyuz essentially identical to the way we dock with the lunar module now. We are also planning to develop and test a device in the center here, collapsible device, which could be viewed with a television camera from the center of the opposing hatch, so that as the two vehicles are brought together, the astronauts can use an on-the-scene view of how the two mechanisms are being brought together, and they will look at it on a display something like this. When alined, one bar will block out the other bar and you won't be able to see the dashed line underneath; that is, the solid bar will cover the dashed bar.

In future programs also, part of the problem with designing docking aids has been that the exact location of the docking mechanism has not been determined. For example, in the shuttle there are still a number of possibilities being explored, but it does seem very clear to us that there will need to be some additional aids—that is a viewing aid for the astronauts to accomplish docking—because it may well not be conveniently located relative to the cockpit. We don't expect it will be easy for them to see both the controls in the cockpit and to see the docking mechanism which might be far removed from the cockpit area, so we see the need in our own program for having something in the area of the docking itself to help them null out any miss distance or alinement that occurs immediately prior to the engagement of the rings.

MANAGEMENT OF ENGINEERING PHASE

- FINAL AGREEMENT ON MANAGEMENT DOCUMENT FOR THE PROJECT WILL BE REACHED IN JULY
- PRESENT U. S. PROPOSAL IS STRUCTURED WITH PROJECT DIRECTORS AND FIVE WORKING GROUPS
- REGULAR AND DIRECT CONTACT WILL BE PROVIDED THROUGH COMMUNICATION LINKS AND VISITS AS REQUIRED
- DEVELOPMENT OF COMPLETE PROJECT SCHEDULES, COMMITMENT TO MEET THIS SCHEDULE, AND REGULAR REVIEW OF SCHEDULED ACTIVITIES
- DEVELOPMENT OF DOCUMENTS DEFINING DESIGN REQUIREMENTS, AGREEMENTS, PLANS, PROCEDURES, TEST RESULTS, ETC.
- FORMAL REVIEWS FOR JOINT APPROVAL OF THE DESIGN AND FABRICATION OF INTERACTING EQUIPMENT AT SELECTED STAGES IN THE DESIGN CYCLE
- CONDUCT OF JOINT TESTING OF CERTAIN COMPATIBLE EQUIPMENT - (FOR EXAMPLE: DOCKING MECHANISM)
- NECESSARY TRAINING OF FLIGHT AND GROUND PERSONNEL WILL BE CONDUCTED
- FLIGHT OPERATIONS PERSONNEL WILL BE IDENTIFIED TO WORK TOGETHER ABOUT 2 YEARS BEFORE FLIGHT

FIGURE 15

MANAGEMENT OF REAL TIME OPERATION

- EACH SPACECRAFT WILL BE CONTROLLED BY THE RESPECTIVE CONTROL CENTER
- CONSULTATIONS BETWEEN CONTROL CENTERS WILL BE HELD FOR DECISIONS AFFECTING JOINT ELEMENTS
- JOINT ELEMENTS WILL BE CONDUCTED ACCORDING TO MISSION DOCUMENTATION, INCLUDING CONTINGENCY PLANS
- PRE-PLANNED EXCHANGES WILL BE PERFORMED ON A SCHEDULED BASIS
- THE HOST COUNTRY WILL HAVE PRIMARY RESPONSIBILITY FOR DECIDING APPROPRIATE ACTION FOR A GIVEN SITUATION IN THE HOST VEHICLE
- ANY TELEVISION WILL BE IMMEDIATELY TRANSFERRED TO THE OTHER CONTROL CENTER
- AS A MINIMUM, FLIGHT CREWS SHOULD BE TRAINED IN THE OTHER LANGUAGE WELL ENOUGH TO RESPOND AS APPROPRIATE TO ESTABLISHED VOICE COMMUNICATIONS

FIGURE 16

I have summarized here in these last two slides (figs. 15-16) some of the agreements which we have made, and a number of these points have already been touched upon here this morning. As I mentioned, part of the reason for our going to Moscow in April was to be sure that we had an understanding with the Soviets as to how we would organize and control this project. In that connection, we gave them a series of documents describing how that would be done. They had studied the documents by the time we got there. They had no specific objection to any of them, but we did agree that final agreement would be reached in July, on the basis of the documents that we provided. I have listed for you then specific things which we have discussed with the Soviets, and which we have found agreement on.

We have proposed to them that we have project director and now five working groups. Up until now we had three. This does not seem to be any real problem. We expect the groups can be expanded in the future as required.

We agree that regular and direct contact will be provided through communication links and visits as required. We made a strong point of being sure that we understand each other on the development of complete project schedules, commitments to meet the schedule, and enough review regularly so we know that we are meeting them. In this connection, we have provided a document of project schedules for example purposes. Our intention is to describe in some detail in July precisely what points in the schedule will have to be met by what activities, what stages of design completion, et cetera, and agree on those schedules in July.

We agreed on a set of documents which define the design requirements; that is, how big it is, how fast it closes, how much the loads are on the docking mechanism, et cetera.

Also in this area we would agree on documents defining the mission plan, the flight plan, the crew, courses of action which I described earlier.

We agreed that we would have, as we do in our own program, selected points which we would formally review and approve the design and fabrication of the interacting equipment, and I should again point out that this activity is primarily oriented to those devices which have to be made to work together. Actually, the internal preparation of the command module and service module is essentially a job which we would do in our country. These reviews would be for the equipment which has to be made to work together.

We would also have to do some joint testing of compatible equipment; for example, the docking mechanism, which would be tested in various stages and with various units during the design process.

We agree that there will be necessary training of both flight and ground personnel, and this will be conducted in either country as agreed training plan would dictate. For example, we would identify what training our astronauts should have in the Soyuz, in terms of both the normal time line that they would go through and the possible contingency course of action which we can foresee. Similarly, we would expect to train and make understood the application of our equipment for Soviet cosmonauts.

We also agree that we will, prior to the flight perhaps on the order of 2 years, identify key personnel in the flight operations part of our business. By that we meant the men who would direct the operation from the control center and our astronauts. They at this time would begin also to work in the working groups in the definition of the project which we have laid out.

On the last slide again a number of the subjects have already been touched upon. We have agreed that each space craft will be controlled by the respective control center. We have agreed that consultation between control centers will be held for decisions which affect the joint elements. Joint elements will be conducted according to mission documentation, which we plan ahead of time including contingency plans which we also plan ahead of time. Again this is entirely consistent with the way that we run our present programs.

We would agree on a series of preplanned exchanges. For example, data information, tracking information, voice information would be exchanged on a scheduled basis and then on an as required basis for problems that might come up.

The host country will have primary responsibility for deciding what the appropriate action would be for any given situation in their vehicle. For example, if there were a problem in their life support system, they would interpret that problem and then instruct our astronauts and our control centers as to what the course of action ought to be.

We have agreed that any television that would be taken would be immediately transferred to the other control center. I didn't make that clear in my discussion of the docking module, but in the transfer of our astronauts over there, we would expect them to hook up umbilicals as they progress through the series of hatches through the Soyuz vehicle so they would have a speaker box back to the command module which permits communication with our control center and

also a television camera which could be routed back through the command module for transmission to our control center.

As a minimum, we have agreed that flight crews should be trained in the other language well enough to respond as appropriate to established voice communications, and as a goal we want both countries, astronauts and cosmonauts, to be as fluent as possible in the other language. I think that summarizes it.

Mr. TEAGUE. Which do you foresee as the biggest problem, equipment or humans working together?

Dr. LUNNEY. In my mind the biggest problem we have is the management part of this problem, that is the humans working together across a large distance and somewhat new to each other, with different backgrounds probably. We have some advantage going for us in our kind of business in that we are both working with the problems of nature, which can be pretty well described by equations and laws that we have developed over the years, but just the overall problem of working together will no doubt be the toughest part of this project.

Mr. TEAGUE. It would be most unfortunate if there had to be a decision made and it turned out that something happened and the Russians either blamed the Americans or if it went the other way and the Americans blamed the Russians. We would lose the whole value of our effort that we are putting forth in this field. Are there questions, Congressman Hechler?

Mr. HECHLER. Yes, Mr. Chairman.

As a student of history, I can't help but be gripped by the historic significance of what is being described. It is a few months less than 15 years ago when the Russians launched Sputnik, and that sent shock waves not only throughout the American scientific community, but it shook Congress and the Nation to its foundations. NASA was established as a direct result of that in 1958, and this Committee on Science and Astronautics, of which Chairman Teague and I and several other members are charter members was established in 1959.

I can't help but be struck, in listening to the discussion at this point, by the contrast in the type of hearing that we were holding in 1959 when this committee was first established, then the entire thrust of our discussion was how we could competitively in a hostile aggressive way launch the space program in competition, direct competition to the hostile nature of the Soviet Union. Certainly a discussion like this could never have been held in the early days of NASA or this committee. It is for this reason that I would like to commend NASA for all the forward strides accomplished in developing this program, and also commend you, Mr. Chairman, for holding these hearings. I think they are of tremendous historic significance in the whole sweep of history of the space program.

Certainly the competition was extremely valuable and will continue to be valuable in furthering the space program. I feel we have now, I believe, achieved a great breakthrough in the nature of the developments that you gentlemen are discussing and have achieved.

It is significant that we are not arguing emotionally over "whether", but we are talking about "how". That to me is a great breakthrough for the world.

Mr. TEAGUE. Mr. Wydler.

Mr. WYDLER. Thank you, Mr. Chairman. I would just like to say I am also glad to comment on the statement of the gentleman to the effect that that was a healthy competition and one which we want, but I would like to yield if I could, Mr. Chairman, to Mr. Goldwater.

Mr. GOLDWATER. Thank you, Mr. Wydler.

I have a couple of questions for Dr. Lunney and Mr. Myers.

The total cost of this effort have you projected that? Let's break it down. What new type of equipment are we going to be asked to build, and what are the related dollar costs which you are projecting at this time?

Mr. MYERS. Basically the new equipment is the docking module with what I call an open loop environmental control capability within that docking module. That is the oxygen and nitrogen bottles that you see on the outside of that module which will be a pressurizing system so we can pressurize to the full pressure of the Soyuz device or down to the levels of the command module. Other than that, the Apollo system equipment generally is going to be used throughout.

We are not changing communications equipment or equipment within the command module itself. The total cost of the program is estimated to be \$250 million, and the costs in fiscal 1973 we had previously studied on the basis that if we were to enter into this program, we would hope to use funds included in our 1973 budget for the Skylab program. We frankly were planning for a very successful Apollo 16 so that we would not have major dollar expenditures to overcome the problems that would develop with Apollo 16. We were fortunate there. Apollo 16 was a very fine mission, and so it appears that in the 1973 funds we can use money from the Skylab and the Apollo program to cover the 1973 portion of it. However, that of course makes it very critical that the budget that NASA submitted be authorized. I hope that does come about.

Mr. GOLDWATER. Approximately how much in dollars for 1973?

Mr. MYERS. Our estimate on that is \$37 million in fiscal 1973. That is the money that we would pull from Apollo and Skylab to support the activities during this year. Total dollars that are involved include also the launch crews and what we call the backup engineering activity for the launch operation itself in 1975. We are still in the process of developing the techniques that we will use to bridge the gap between the end of the Skylab program, which is the end of calendar year 1973, and the time of this launch in 1975, where we will need to retain and be able to go back to the capability of supporting a mission like this in the 1975 time period. This is also a major management job for NASA to work across this gap in 1973-75. We think the preliminary planning we have put into this shows that we have enough continuity in the command and service module activity to have engineering support at the time of the launch of the command service modules and as far as the S-1-B launch vehicle is concerned it is used in the Skylab program and we have a great depth of experience at Marshall to support that carryover of knowledge out to the time of launching the command and service module in 1975.

Mr. GOLDWATER. So you do have everything but the docking module. Everything else is already available.

Mr. MYERS. The docking module itself is really the new piece of equipment that is involved.

Mr. GOLDWATER. This, I am sure, is premature, but could you estimate how many jobs this might create?

Mr. MYERS. We have made an estimate that at the peak of the program we would have about 4,400 people working on the program. We always have difficulty with this in discussing it, because it isn't as if it were 4,400 new jobs. The space program's general employment levels are decreasing with time, and so the 4,400 in many cases is the retention of those 4,400 people over and above that which we would have had we not gone into this program.

Mr. GOLDWATER. The peak time being?

Mr. MYERS. The peak time is the end of 1974. That is where we peak on the employment involved here.

Mr. GOLDWATER. Do you have any idea who is going to be building this, or is that still out in the future?

Mr. MYERS. It hasn't been settled completely yet. We are recommending that we go to North American to build the docking module, because the interaction of the docking probe and drogue is intimate to the design, the part that is like Apollo. The devices inside the docking module itself are parts from the command module. The structural design, testing, the kind of background that is involved in this area is directly and immediately available to us at North American, and we are recommending to the Administrator that we go to North American for this activity.

Mr. GOLDWATER. Just in closing, I might comment that I am sure there is a tremendous amount of political value to be had by docking with a Russian vehicle. Dr. Lunney mentioned that at this present time there are no real joint experimental activities that have been defined. It would seem to me that perhaps that would be an important aspect of this mission outside of politics.

Thank you.

Mr. TEAGUE. Mr. Downing.

Mr. DOWNING. Thank you, Mr. Chairman.

I want to commend the chairman for holding these hearings. I think they are timely and interesting.

It is certainly, I think, a step forward to bettering the relations between the two great superpowers if it works, Mr. Chairman. If there is disagreement it could be a debacle. I was wondering what was the attitude of the Russians in these negotiations. Were we the aggressors in this cooperative effort? Just what was the Russian attitude.

Dr. LUNNEY. Throughout all of the formal meetings in which I have been engaged, I have been in all of the meetings that we have held, throughout this set of discussions the men that we have dealt with have been very sincere and very interested and very cooperative in trying to achieve the compatibility that we have discussed here this morning. They have been very aware and have mentioned on a number of occasions the humane purposes of being able to rescue cosmonauts or astronauts as a result of this capability. This improves the potential for doing that.

They also allude to unspecifically as we do also the possibility of joint cooperative efforts, but in a general sense throughout these discussions they have been very forthright and have answered questions and have tried to come up with solutions, and when we have run into

impasses, they have tried to have a discussion which would allow us to resolve any difficulty and move on with the work, so that the discussions have been conducted in a very strong environment of good will, good faith, and a willingness to find the correct solution to the problems. We both have entered these discussions with a background of manned space flight both in terms of the successes that you can have and in terms of the difficulties that you can run into if you don't fully anticipate and prepare for things that can happen.

Mr. DOWNING. Thank you very much. Thank you, Mr. Chairman.

Mr. TEAGUE. Mr. Bergland.

Mr. BERGLAND. Thank you, Mr. Chairman.

The gentleman from Virginia asked a question I was going to, but I do have one more. How many men will be on board each of the American and the Russian vehicles?

Dr. LUNNEY. The Soviets have already indicated to us that they would fly their ship with two cosmonauts. It is possible to fly it with three, but for their own reasons they have decided on flying two.

In our country we are still evaluating whether we should fly with three astronauts or two. The factors that go into trying to decide that are a better definition of what the transfer sequence would be back and forth between the two vehicles, a better understanding of what experiments we might carry because, depending on how big or small these experiments are, there is either more or less room in the command module for our three men, so in our case we have not yet decided whether the best number is three or two.

Mr. BERGLAND. In the event that either the American or the Soviet craft should fail in this exercise, would there be room on board the other vehicle to bring all the men back to earth?

Dr. LUNNEY. In looking at the reentry module of the Soyuz, I find it hard to believe that you could put up to five people in it. Three men now are probably very crowded. In the Apollo vehicle, we can make standard provision for three men to return, but we would not expect to have a couch provision for five men to return. I think if we were faced with that, one would try it in the command module. I think we could find ways of putting people in and moving them up on the couches after we get the main chutes open which would allow people to survive. It might result in some injury, but, on the other hand, if one was faced with an either-or condition in orbit, I think we would arrive at that conclusion with respect to our ship.

I have given you my version of what I think the answer would be relative to the Soyuz, but that also would need, of course, an opinion from the Soviet Union.

Mr. BERGLAND. The Russians regard this as just a first step toward a whole series of international exchanges in this area, or do they look upon this as just kind of a novel experiment?

Dr. LUNNEY. I think they look on it as a definite step in the direction of cooperation in space. They have stressed the humane and rescue aspects of the mission to us a number of times, but they have also discussed the possibility of considering later on cooperative missions.

They obviously have taken the attitude, as I think our longrun attitude should be, that human beings are in space to stay, and there will be plenty of work to do and plenty of things to be done in space, es-

pecially in earth orbit; and these provisions for rendezvous and docking between vehicles is a very logical and inherent part of the overall effort that mankind is engaged in.

Mr. FRUTKIN. I think we should point out two aspects to the Moscow agreement. One is the immediate test mission, and the other, a commitment that future generations of space craft will be compatible so there is the long-range commitment as well.

Mr. BERGLAND. Thank you very much, gentlemen. Thank you, Mr. Chairman.

Mr. TEAGUE. What is the physical facilities for meetings like this? How about the interpreters? Who presides at the meetings?

Dr. LUNNEY. We have done this so far. We have organized the work according to three working groups. We now see the work has expanded to where it ought to be more than that, probably five. The three working groups have chairmen from each country. Until the present, I have been acting as chairman of one of the groups, and two other men from Houston have been chairmen of the other two groups. For example, today in the first working group we consider the overall aspects of rendezvous and putting the mission together, the overall programmatic and working group considerations. Working group 2 is primarily concerned with radios and lights and docking targets. Working group No. 3 is primarily concerned with the physical docking mechanism which has to mate together. These three groups, cochaired by an American and Russian, meet separately, discuss the problems according to a prearranged agenda. We always have discussion before we start the meeting as to what the agenda will be. Then we proceed to establish a schedule for conclusion—that is, when we will have the minutes—and the work proceeds from there. Several times during a period of a week or 10 days, we have reviews with other people. For example, when we were in Moscow, Dr. Gilruth and Dr. Kraft were with us, and several points during about a week's worth of discussion we raised and discussed—that is, the chairmen of the working groups would break off and discuss with the leadership, what the progress throughout was, what the problems were, and what the overall situation was—so that at all times we had a pretty good feel for how the discussions were going and where if anywhere we were running into any problems.

Probably now we will move to the point where the project directors, myself and Professor Bushuyev from the Academy of Sciences, will have a full-time job with the matter of the organization, the schedule, the planning of the activity for the meeting, et cetera, and we will have separate chairmen for each of the working groups, including the one that we are now actively chairing.

We try to prearrange the meetings by letters and telegrams outlining agenda items, subjects that we see need for discussion. Then in the meetings, we have found that we generally bring an interpreter for each working group, plus an extra one to take care of discussions which are held outside the working groups—that is, the management kind of discussions outside the working groups—and I think that we will as a minimum need to have an interpreter for each working group and an extra one for the management aspects.

As a matter of fact, we found that interpreters can turn out to be the most overworked people in the meeting. Extra interpreters are

very valuable, both in terms of formal discussions and in terms of informal discussions which can provide information and exchange. We have also had to buy a couple of typewriters that type in the Russian alphabet. We have those available now in Houston, and that kind of logistics translating documents into the other language, and then checking them to be sure they are right, it is kind of a new problem for us. It takes time, and you just have to allow for it in the planning of the meeting and the planning of the timing of the work that has to go into that meeting.

Mr. TEAGUE. Mr. Frey, do you have a question?

Mr. FREY. Just one, Mr. Chairman. I just wonder about the breakdown of jobs, the 4,400, how are they going to be spread out?

Mr. MYERS. The best estimate we have at this time is that of the 4,400, there are about 1,900 that would be in the Southeastern United States. These numbers aren't completely nailed down yet because we do, as I mentioned earlier, still have ahead of us the problem of planning for that gap in operations between the Skylab and this mission, and details of that are still underway, looking at the methods that we can use to best retain knowledge of the S-1B-CSM at the lowest cost.

Mr. FREY. What hardware are we going to have left after we use this?

Mr. MYERS. Our present planning calls for the Apollo-Soyuz test mission, ASTM, in about 1975. There is still a 2-year gap before the period of vertical launch of the Shuttle so we still have some problems in carry over of the manned space flight capability.

Mr. FREY. What hardware do we have left?

Mr. MYERS. In this program we are using CSM 111 which has been completed and checked out in storage. We would use the command service module 119, which is the device that presently is planned as the backup for the Skylab program. Assuming that CSM 119 is not used as a backup for Skylab it would become available for backup to this mission. We then have two S-1B launch vehicles, one of which would be planned for then flight, and one that would be a backup.

Mr. FREY. If we decided somewhere down the line to supply more money to go ahead with another Skylab, do we have enough hardware left to do it?

Mr. MYERS. We would have just enough with this one ASTM mission in operation, and assuming we don't need the backup hardware for the Skylab, we would have three CSM's total. I didn't finish in my discussion there; there are the additional CSMs 115 and 115-A which are in various stages of assembly at North American Rockwell in California, so we end up with four total CSM vehicles, after the Apollo program, not specifically committed to flight.

Mr. FREY. One last thing which you might have covered before, but I was interested in these discussions. Has there been any talk or exploration of a further type of mission with the Russians after the initial phase?

Mr. MYERS. There has not, but as we did testify earlier, we see this as an opportunity, over a period of time, to naturally lead in the direction of joint missions with the possibility of elimination of duplication in activities between the two countries, and eventually joint missions. But nothing is definite yet.

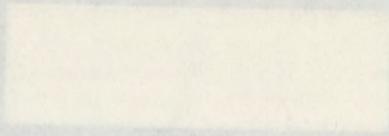
Mr. FREY. You have done a great job of putting this together over a period of time. Thank you, Mr. Chairman.

Mr. TEAGUE. You don't foresee this as a continuing squeeze on the Skylab or Shuttle as far as money is concerned, do you?

Mr. MYERS. No; I don't. The way we did our planning was to look at the possibility of one mission of this nature. If there were to be any additional missions, which I would hope would come into being over a period of time, it certainly would require in some degree an addition to the NASA budget.

Mr. TEAGUE. Thank you, gentlemen. The meeting is adjourned.
(Whereupon, at 11:55 a.m., the subcommittee adjourned.)







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