Talk by Robert R. Gilruth to USAF Scientific Advisory Board
Site: Chandler, Arizona, Nov. 7, 1961

"next speaker is an old friend of the SAB Mr. Robert Gilruth who is Director of Manned Spacecraft Center at NASA. Bob has served on the SAB and has been here often to give us presentations and enter the discussions. As you all know he started in aeronautics a long time ago and worked in the general field of stability and stability criteria and did some very fundamental work in that field of aeronautics and then after the war when transonics became important he led in the development of rocket launching and radar tracking devices to study aerodynamics of test vehicles and again when space flight came along his interest and capabilities led him to the job heading our manned space venture. It is always interesting to me to see that most of the fundamental problems that he worked on in airplanes are defenseful and these tests rockets are defenseful problems that he has today. He's a little bit like the Austrailian aborigine _____ who was given a new boomerang for Christmas and he had a hell of a job throwing his old one away. Bob Gilruth will speak on NASA's space vehicles current and future concepts."

Mr. Gilruth: Thank you, Guy. I wish I had a real fast come back for the boomerang but I'll have to pass and think of one later. Mr. Chairman, Members of the SAB, and distinguished guests. It is a great pleasure for me to be here with you and I must say that I found much to agree with in the very excellent statements that have been made here in your meeting. I refer to such statements as made by General Gearheart (sic) Dr. Kavenau and General Schriever yesterday. The NASA activity in manned space flight started 3 years ago, 3 years ago in October. Actually, it was one of Keith Glennan's first acts as the new administrator to get going with Project Mercury. During that period of time we have taken manned flight in space from a concept to hardware and trained crews. That required going through R and D, design, ground tests, flight tests, modification, and training. We built an earth circling network as ~~far as the~~ part of support for the project. We have now verified in flight all the spacecraft systems including the pilot and have recently completed one orbit and completely automatic ~~all button~~ recovery on last September the 13th. ~~Now~~ My first slide shows the makeup of the Project Mercury team. I don't expect you to read all the fine print. ~~Here, this~~ In the center is our organization (the Space Task Group) and the management organization. ~~here these~~ On the left side are the agencies that have been involved with us in the R and D. These are the ~~latest~~ Various NASA research centers and I have listed here USAF, the Army, and the Navy who have contributed. For example USAF has contributed greatly to our R and D with ~~great use of~~ their biomedical capabilities. Tullahoma has also been used along with many other facilities, Holloman, and the School of Aviation Medicine. In the Navy our principal use has been of the Johnsville centrifuge and their ~~nearby~~ bio-medical capabilities. We've gotten strong support from the Army in many of the areas that General Shoenberg mentioned yesterday. In the Space Task Group we have basicly five divisions, Engineering, Flight Systems, Life Systems, Flight Operations, and Preflight Operations. These divisions ~~Which~~ have overseen the production work, recovery operations, and launch operations. I think the agencies involved in these operations ~~here~~ are self explanatory. To the right ~~This~~ is the group that implement the network. Western Electric was the prime contractor. On the lower right ~~and this~~ is the group that operates the network. ~~Light off please.~~ Mercury recognized from the start the predominance of man in the space mission. We knew we had to create ~~a spacecraft that weighed less~~ then 3,000 pounds. The basic ~~set of~~ ground rules we followed for the project are shown on the next slide. The reason for the 3,000 pounds ~~continue~~ is that we intended to use Atlas with its guidance system which was very precise and very suitable for the kind of operation that we had anticipated. We planned ~~tried~~ to use a blunt reentry body with retro rockets for removing it from ~~kicking out of~~ orbit. The key development for this blunt reentry body is the supine couch for the pilot which allows a man to withstand the reentry loads and even up to 20 g's in the case of abort from ~~in~~ the worst possible situation. We planned for Parachute landing on water;

this, of course, ~~if~~ is necessary because many of our flights are to be unmanned or with animal passengers. We planned for an automatic escape system; I think the reason for this one is obvious after Dr. Golovin's ~~Mr. Sullivan's~~ presentation on booster reliability. It's a little discouraging to me that it appears that the next generation of booster ~~rockets appears that they are not doing too much maybe go the other way from~~ may not be much more reliable than the ones we have had to work with so far. We have on the Atlas a 2 second warning ~~from that we had~~ time in which to escape from ~~it~~ a possible high-yield type explosion. We also ~~touched on~~ foresaw the need for a ~~projector~~ progressive build up of ~~teeth~~. By using these basic concepts we've come up with a spacecraft that looks like ~~the next slide~~ that shown on the next slide. ¶ This is the Mercury Spacecraft. It is 74 1/2" in diameter and about 29 feet long including the ~~this~~ escape tower. ~~Here's~~ a little larger view. ~~By means I describe some of its structure this is~~ On the right is the blunt end ~~that~~ reenters first. Of course, by the time of reentry the retro rocket package has been jettisoned. The blunt face is made of an ablative fiberglass and plastic. ~~abrasive shell.~~ ~~The afterbody~~ The shingles are bolted on using washers and large holes so they can expand without wrinkling. The shingles are made of a refractory ~~expensive~~ metal .016-inch thick. Underneath the shingles is a layer of insulation and ~~are installation then~~ underneath that are ~~is~~ two layers of ~~10,000~~ .010-inch thick titanium which forms the pressure vessel. ~~This is in our~~ The Vycor windows have two layers, an outside layer to withstand the high temperatures and an inside layer to withstand the pressure. ~~This pile like I said here is helium~~ The cylindrical section is covered by beryllium panels. They are also mounted in a way so that they can expand without generating stress. The final conical section ~~This is, of course,~~ is the antenna canister and the parachutes are packed inside the cylinder. ~~here~~. ¶ The next slide shows the internal arrangement of the Mercury capsule. As you can see the density of ~~the~~ equipment is very high. Most of these major systems are indicated in this slide; ~~here besides~~ it shows the control systems, ~~by the means of which we control the outside jet~~. ~~These are~~ the two parachutes (the main parachute and the reserve parachute), the horizon scanners ~~here~~, oxygen supply, various sequencing systems, life-support systems, communication systems, and power systems. ~~Now~~ The next slide shows the three boosters that we have been using in the program. This the Little Joe which we developed especially for the Mercury project consists of a rockets, it has about the same performance as the Redstone which is used for the qualification of the spacecraft and the early man flights such as Shepard's and Grissom's and of course the Atlas which will be used for the classification mission. I would like to talk just a moment about some of the basic technical problems that we are having and what we have learned; these are listed on the next slide. First one Spacecraft in the systems — we found in our initial early R and D flight tests that the picture of heating from the wind tunnels was not quite accurate and was a concentration of heating on the afterbody that the section. that I mentioned which covered a filed. This was a change that was necessary after one of our first flight tests. Another difficulty that we had to correct in the orginal concept was land landing. We had to fly a inside to obtain where certain conditions of abort a land landing would occur. Pilot selection and training the next item I would say here the original concept was very good, we are well satisfied with the techniques used and we are well satisfied with the criteria pilots using test pilots, experieced tests pilots test pilots fuel the amount of jet time and I would say that this is one area in the future work on Apollo that we can come close to predicting a retime training. This little item here is the whole story in itself. In launching a manned satellite the problem is a bit different than in an unmanned one in that you want to know the real time what the orbit what the trajectory is and whether or not your getting a good orbit. This of course led to the development of a control center at Canveral and the wordwide range as I mentioned earlier. Basicly the problem is one of giving the flight director on the ground a picture in real-time of the trajectory and also the behavior of the onboard systems. If an abort is indicated he can so advise the pilot immediately, for example, if as you lift up to 60,000 feet, if the pilot has not recorded that the systems are all good and if the flight Director sees ~~the~~ a loss of oxygen pressure, he would command an abort. ~~and it is just so you know this right now.~~ Another problem was ~~are~~ to automatic versus ~~this~~ manned control. ~~now a new mercury has~~ In Mercury we had to provde a completely automatic system because of course we had to fly animals first. ~~and~~ At the same time we wanted to use as ~~maximum~~ much of the same hardware as possible, when we got the manned flight, and we wanted to give the man as much override as possible to take advantage of the extra reliability. This gave us ~~is so the~~ problem of complexity which ~~you~~ would not ~~have~~ exist if we could have ~~if you could go~~ gone with a unmanned vehicle all the way. Such little things as ~~like~~ the development of the "cherry picker" to stand by the launch pad to resque the man in case of trouble on the pad when we ~~which you~~ did not want to use the automatic escape system or if for some reason that was a malfunction also created problems. There are a million details like that ~~you~~ have to be ~~have to~~ worked out in this kind of an operation. ¶ ~~Now by the way I brought with me [illegible] a film called Freedom 7 which shows you the background and actual flight of Alan Shepard last May, which if there is interest here in the group I will be glad to show [illegible] later on in the day or perhaps the evening. I think it is quite revealing in the~~ depth of ~~details and planning and~~ preparation ~~that has to go on in this kind of a flight operation.~~

do not delete

¶ The last item is Booster-~~Mercury~~ Spacecraft integration. I think ~~it~~ it would be hard to conceive of a simpler type of spacecraft to integrate with a booster than Mercury. It is symmetrical, small, and ~~small~~ has ~~had~~ no lifting surfaces and yet this is an area where we experienced considerable trouble. We had a structural dynamics problem ~~[illegible] dynamics trouble~~ between spacecraft and the booster ~~and I would say this again that we had~~ which was not anticipated as ~~this~~ being a problem when we started. ¶ ~~Now~~ The next slide shows ~~shot is~~ some of the nontechnical problems. In an operation like this, I think many of you recall that during the last few years there has been considerable controversy led by some our most distinguished scientific types as to whether there was any point in manned space flight ~~any of this~~ anyhow. This feeling has ~~is~~ largely evaporated but at the time it had a quite serious effect. It seems to me as an intimate participant in this program that the general public was probably less confused by what the real values were in such flights ~~this~~ than were some of our scientific leaders. Another thing that is involved, it was quite obvious, although I think it is largely accepted now is the lack of precedent for ~~presidence of~~ this type of spacecraft. I think we have all been used to thinking of wings. I would say that it looks a little peculiar to people as a manned flying machine. ~~One of the great things~~ jokes in the last few ~~10~~ years that came to us ~~come~~ from ~~Edwards and other test pilots centers~~ was "~~When are~~ you going to pack your bananas and get down there with Project Mercury?" This feeling is also largely been dispelled. Public information is a field quite new to me since I have ~~having~~ worked all my life on classified projects. ~~since~~ You all realize that projects such as this are entirely open to the public; they have access to all hearings, all schedules, all costs ~~and they~~ you have about a million reporters ~~today~~ clamoring to see you or the astronauts or something about the project. Then of course, as we brought out yesterday, our ~~the~~ position relative to the Soviets didn't make it any easier. They, as General Watson showed, ~~they~~ started considerably before we did. We knew we were in a "trying-to-catch-up" position, but dealing with the public information ~~so all of these items here I would say summarize~~ aspect was possibly the principal nontechnical ~~kind of~~ problem. ~~Another slide.~~

To summarize, then, our present position. We have taken Project Mercury ~~it~~ from a concept to the actual hardware and trained flight crew. The specification manned orbital flight is now imminent and ~~intimate~~ should occur within the next few months. Manned flight in space has become, with President Kennedy's public announcement on May 25th, ~~has now become~~ a ~~our~~ national goal. I would say also that acceptance ~~the preference~~ of new concepts by both the public and by the technical community has been largely achieved. ~~received.~~

I would like to move now to the next project, Project Apollo, the program for ~~along with the one~~ which Dr. Golovin ~~Dolliven~~ was covering the transporation end. Apollo started up at Space Task Group in early 1960. By about May of 1960 we knew from ~~the~~ inhouse study of what the next step should be. We drew up guidelines for the project — whether it was to be land or water landing, or both, the kind of reentry problems, and so on. We also brought in very shortly thereafter three industry contractors to continue the study. This past summer we briefed the entire aerospace industry in Washington on our inhouse studies and on the results of these three contractors' study efforts. Last October we issued a request for "proposal" to the aerospace industry. We have now received the proposals from 5 major industrial teams and they are being evaluated. The contract will be for the Apollo spacecraft. We hope to have the contractor selected at least by January 1st. As Dr. Golovin told you the booster for this mission is under study, direct ascent versus. Also NASA has reorganized to handle manned space flight.

I would like to show very briefly what some of the concepts are for the Apollo spacecraft. We feel we must have a launch escape system judging from the expected reliability of the new rockets. An interesting thing is that the yield of an exploding booster using cryogenics is basically much higher than one that might use hypergolics. With a hypergolic booster you might be able to use the ejection seat but for this Apollo mission you will need an escape system of some kind that will provide the maximum distance between the booster and the spacecraft in the event of trouble.

The next slide shows the concept of the spacecraft. On the left is the command module. This is the module that would go all the way to the moon and back. The reentry body is steered by having the center of gravity offset and controlling it in roll. The service module is used for mid-course steering, fuel and battery storage, and lunar takeoff.

Last is the hydrogen-oxygen stage for lunar landing.

The next slide shows a comparison of Mercury and Apollo. Mercury is one man, Apollo three; 4 1/2 hours for the Mercury, 2 weeks duration required for Apollo. A pressure suit is entirely suitable for Mercury for the short duration but for longer durations we need a much more sophisticated system. The

Apollo, of course, is intended to be both earth orbital and circumlunar as well as ~~and~~ lunar landing. Apollo ~~So it~~ must be a more practical and versatile vehicle than Mercury. We intend to use ~~this~~ the crew, to have the mission commanded from the spacecraft and not plan to make the system sophisticated enough so that you can fly a monkey all the way to the moon and back again. We think this will ~~would~~ save a great deal of time and provide ~~give us~~ a lot more reliability. Reentry velocity of course is stepped up for Apollo with 36,000 feet a second, while Mercury is ballistic, in the case of Apollo the re-entry will ~~it would~~ be controlled, and, of course the booster has been discussed ~~depressed~~. ¶ The ~~Now my~~ next slide shows some of the milestones in the Apollo program ~~I don't know whether they agree with your ________ or not.~~ You will note from these milestones, that we do not ~~felt~~ feel that the spacecraft if going to be the pacing item. This may be wishful thinking because we know a little bit ~~more about~~ the spacecraft configuration right now. The dates are shown for ~~this is flight~~ earth orbital operations in 1964, circumlunar flights earliest possible by 1966 with a lunar landing ~~up here~~ in 1967. ~~now~~ These are dates based on the availability of launch vehicles. ~~Now~~ The next slide shows the powerful effect that rendezvous has on escape payload. The direct ascent ~~situation~~ is shown here with about 120,000 pounds required for direct landing with ~~an~~ a NOVA being able to make it and rendezvousing with two C-4s. ~~now what was the ____ Dr. Sullivan's talk.~~ With lunar rendezvous ~~this the~~ the escape payload is less ~~or thereabout~~ this can be made by C4 or by rendezvousing two C-3s ~~system three.~~ ~~The powerful affect.~~

¶ I would like to turn now to what I consider to be some of the technical problems of Project Apollo, these are shown on ~~May I have~~ the next slide. The first item ~~one~~ has been dealt with at length, but I would just like to take a moment ~~here~~ to give ~~you~~ a feeling as to what the propulsion requirement really is for this mission. It takes 25,000 feet a second to make earth orbit ~~it is~~ about 5 miles per second it, and it takes 36,000 feet a second about 7 miles a second to escape. Now for the Apollo in addition to that, you must have enough propulsion to steer to the proper lunar approach, ~~and~~ have enough propulsion to orbit the moon and to back down on the moon, and then to take off from the moon and steer back to the proper reentry corridor. If you add up all this propulsion and use this simply to go as fast as you could it amounts to about 60,000 feet a second. It is quite obvious that in order to achieve this kind of propulsion you need not only big rockets but lots of staging and the best fuels you can possibly get. That is why this launch vehicle was such an important problem. I might add in passing that many of us here had something to do with breaking the sound barrier — this speed is less than 2 percent of the 60,0000 feet a second that we are now considering. I think Dr. [illegible] covered this question, but I say that our number one problem is how to make these vehicles operate properly particularly when they have so many stages. You may have 90 percent reliability for one stage, but with five or six stages, you must take that 90 percent and raise it to 5 or 6th power. When this is done it is not a good number. Now that is, in my opinion, the number one problem.

A lunar landing, of course, requires landing in a vacuum, a truly soft landing on a surface about which we know almost nothing, while this does not appear an unsurmountable task, the very nature of the unkown may pose some problems we don't anticipate now. Reentry will be from 36,000 feet a second which is the speed where the radiation from the shock waves is beginning to be important, however we think it is within state of the art to handle it.

Radiation from solar flares in space, is a problem; an improvement in our prediction techniques requires some activity and probably we will require some shielding in the spacecraft.

The earth landing is a sort of nagging problem. I don't think any of us from Project Mercury feel that a parachute landing is really a good way to land. We would like to land on the land rather than on water and parachutes are very difficult to use for a land landing. In zero wind they could be all right but you very rarely have zero wind and so your shock-attenuation system has to work not only up and down but laterally and you don't know in which direction, thus some better way of earth landing is badly needed. I think that many of you are familiar with is the Rogallo kite or parawing. That can be tucked in the place of the parachute and can be controlled by the pilot to make a horizontal landing. Incidentally, it looks like it would weigh very little more than a parachute system, but ~~it would~~ will have to be developed. Now this last item is one I would like to dwell on. Flight Operations experience ~~this~~ is something that is very difficult to acquire in space because flying in space ~~the~~ ______ takes so much "doing". ~~And We can see~~ I foresee the need ~~in~~ of a great deal more of operational experience before we set out for this voyage to the moon. ~~Now~~ I would like to address my next part of my talk to this problem. For example, we need more experience on extended weightlessness, this is quite obvious. There is a question whether ~~the way that we seek our problems what problems that seek out the~~ there's ~~were this~~ or were problems that will effect most people. We need the ability to train pilots in space, giving them some time and giving them a chance to rendezvous, to get out of the spacecraft, to develop the kind of personal equipment that will be needed for the lunar expedition. The space suits that exist now are miserable pieces of equipment. Being inside of an inflated spacesuit is something like being inside of a low pressure tire, the mobility is poor, and what we need are some good mechanical engineers working on this job until the joints can be balanced and until we can get a much more reasonable situation. Well, of course, you have to train ground crews for this sort of business, the flight controllers at the ~~various~~ tracking stations, and the flight directors, and so on. These people don't get proper training unless they ~~are~~ work in actual flight operations. So we at NASA feel that we need a vehicle, an operational vehicle, with which can get this kind of experience. ~~and~~ For the past six months we have been studying what we call the Mercury Mark-2 that Dr. Seamans referred to yesterday. This would be a two-man vehicle, it would be launched by a Titan II and would rendezvous with the Atlas-Agena as a target. ~~So~~ On this kind of an operation it would have a delta V in space of roughly 5,000 feet a second for maneuvering. ~~My~~ The next slide shows a cut away of what we are calling the Mercury Mark-2, ~~it's~~ It is a two-man spacecraft with ejection seats. We think because of the hypergolic fuel in Titan II and the consequent low yield from any explosion thatthis will be an adequate escape system. The packaging that we were not able to do on the Mercury because of it's very high density has been placed in bays of the cockpit on either side ~~here~~, so it can be reached from the outside. This, together with the experience we have gained with all of these systems in Mercury, makes us feel that this job is really more of one going from experimental to a production spacecraft than it is a brand new ~~one~~ design. This spacecraft is only [illegible] greater in diameter than Mercury. ¶ ~~Now~~ The next slide shows a missile with which many of you are familiar, it is a two-stage missile 10 feet in diameter. ~~and this of course is second stage~~ The Titan II is a second generation missile in the same sense as the spacecraft is second generation ~~spacecraft~~. The next slide shows some of the pertinent information about the Titan II. It can place about 7500 lbs in orbit. ~~It weighs about 7500 pounds in orbit. It is a second generation vehicle.~~ It has been greatly simplified by the military development program which required that it be able to be launched within a second or two of a prescribed time. It uses storable ~~soluable~~ fuels; this is a very nice thing, not having to LOX at the last minute and hold your astronaut in the spacecraft for several hours while you do this. The starting system is simplified. In our use we would propose to make the redundant guidance system and the hydraulic system in the same way you would try to do on an airplane. With these changes, the reliability estimates are very high. Actual [illegible] estimates are over 90 percent. We believe that translated into reality this would give us something around 90 percent following the initial flights. Another good thing, of course, is the intensive military test program on this missile next year. ¶ The next slide shows something about time scales. We feel that if we can get approval soon ~~going on this thing~~ we can be flying man in 1963 with an extensive long duration and rendezvous experience with in 1963-64.

¶ The next slide shows something ~~Now I would like to say a word or two~~ about the landing of this spacecraft with a controlled re-entry ~~answer the next slide. This is a control the~~. This is the kind of footprint we would expect to get. If the designated actual impact point with no steering were in the center, the width of the footprint [illegible] ~~whether it be here~~ is the kind of direction we could make with the type of steering anticipated for this spacecraft, that is, the offset c.g. and the roll principle. The last slide shows the view of this Parawing ~~carryway~~ as it might be used with the capsule for a land landing; the heat shield would come down and act as a skid. Now we have actually made a flight test, a scale model flight test, of a system like this. North American has made this test for us under contract and they have actually packed a para glider in the same size [illegible] compartment as the parachute system, deployed it in flight, inflated [illegible] and accomplished a complete deployment. So we feel that by intensive work it should be possible to get a horizontal landing with zero vertical velocity for a spacecraft without a large weight penalty. The weights on these things come out about 13 percent of the gross weight, the parachute system is running about 10 percent.

In closing I would just like to say this: It occurred that NASA objectives in this Mark-2 program are so close to the requirement expressed by General Schriever for the Air Force requirement yesterday that it may be advantageous, both to NASA and the Air Force, that they have close participation in a project of this sort."