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In a message to a joint session of Congress on May 25, 1961, the late President Kennedy said that he thought this country should commit itself to putting an American on the moon and bringing him back alive before this decade is out. You all know that Congress and the American public accepted this challenge with great enthusiasm and ever since, this country has been engaged in Project Saturn-Apollo, probably the most ambitious and far-reaching scientific and technological undertaking ever attempted by man.

Before I tell you how we are implementing this plan, I would like to spend a few minutes discussing with you _why_ this is so important. Why do we all of a sudden have to go to the moon? Some people say that the moon has been there for several hundred million years and so far nobody seemed to care about going there. The moon was essentially a subject for astronomers and lovers to worry about. Why is it all of a sudden so necessary to _go_ there? "Or why," as a little old lady said, "must people go to the moon? Why can't they stay at home and watch television as the good Lord intended?"

The statement has been made that this whole U. S. Lunar Landing Program was nonsense. That this country shouldn't be spending 20 billion dollars, to pick up a handful of lunar sand. Well, let me tell you that if picking up a handful of lunar dust was the sole purpose of the exercise, I'd be against it myself. Our objective is really a very different one. The moon is as much the goal of our undertaking as the City of Paris was in Lindbergh's immortal flight. Of course, Paris was Lindbergh's goal, but the real objective of his flight was to demonstrate that the time had come when airplanes could cross the Atlantic. He knew that by chosing a goal that was universally understood, he would set forces in motion that would ultimately lead to commercial flights across oceans and across continents. History has shown that he was right.

Why are we going to the moon?

Basically, we are going to satisfy our curiosity. Man, ever since he crawled out of the cave, has shown an innate curiosity to know about what is under the rock, what is beyond the hills, what is at the bottom of the sea, what is on the other side of the ocean. And now he wants to know what it is like on the moon, -- and on the planets. I think we have ample historic proof that, in some mysterious way, it seems to pay off for man to satisfy his innate curiosity. Our entire progress in science and technology, indeed everything we call civilization, can be traced back to the fact that at some time, at some place, someone was curious about something.

As long as man kept satisfying his curiosity, things moved ahead.

President Kennedy, in one of his later speeches, said "Space is the new ocean, and we must learn to sail on it."

I think this is probably the finest and most concise definition of the objectives of our national space program. We must learn to sail on that new ocean out there. We must build a national space flying capability. Now while this is easy to understand, it is not quite that easy to describe an adequate program to develop such a national space flying capability. You see, space all by itself is not a program. Space may be a challenge, but basically it is a place. And it is a unique place in that it has three dimensions, all three leading to infinity. Space is one of the very few places in the world that is even bigger than Texas.

Now the question whether you should spend one dollar or a billion dollars or a billion billion dollars on a program to sail on that new ocean of space, is hard to answer. For no matter what level of effort we establish for this program, we are not likely to make a dent on outer space itself.

Thus it is kind of difficult to reach universal agreement on what is an adequate program to explore outer space, to learn to sail on that new ocean. It was for this reason that President Kennedy decided we must come up with a limited goal that was clearly spelled out and universally understood. He elected "An American on the moon in this decade" as this limited goal. Everybody knows what the moon is. Everybody knows what this decade is. Everybody can tell a live American astronaut who returned from the moon to tell the story from one who didn't. Here was a goal that was understood in the darkest part of Africa as well as the most sophisticated circles of the United States. With the national commitment to go there, the moon has become our cosmic Paris.

There's one other very practical aspect to such a clearly defined goal. It was obvious that the objective of putting an American on the moon and bringing him back in this decade could be met only by a determined program extending over quite a few years. We scientists and engineers could now sit down and design a well laid-out and hard-hitting 8-year program. We could define what rockets were required to get our astronauts to the moon and back. We could define what facilities were needed to assemble, test, and launch these rockets; what kind of industrial contractor teams had to put together to develop the various engines and stages of these rockets, and their ancillary equipment; we could define the spacecraft wherein the astronauts would ride, maneuver and reenter the atmosphere at the end of their voyage; we could define a training program for the astronauts and after we had thus defined the entire program, we could price it out and go back to the Congress and say, "You gentlemen have heard what the President suggest. You yourself have endorsed it. Here is the bill."

And this bill did not cover just Fiscal Year 1962 or 1963 or 1964. The Congress, in adopting the program, knew full well that there would be continuing bills for Fiscal Years 1965, 66, 67, 68, 69, and 70. The

Congress, in buying the program, therefore, made a decision that can be compared with the decision of a family buying a new car. Regardless of whether there had first been a little squabble as to whether the family could really afford that new automobile, after the decision has been made, the contract signed, and the car delivered, it was clear to every member in the household that those monthly installments would come with relentless regularity. For any installment buyer of a car locks himself in. If he has any second thoughts about his decision, he is squarely confronted with the dilemma that if he stops the payments, he will lose both his car and all of his previous installments. That is precisely the situation today with our space program. We, as a nation, have decided to buy a car. We have made the initial payment. We have built the facilities and assembled the industrial teams. We are beginning to get our money's worth. If we now changed our mind, as has been suggested in some quarters, all that will be left of our glorious space program would be some rather impressive monuments to our half-heartedness in the face of a great issue. Those huge steel and concrete test stands for our Saturn V moon rocket will sit there like the Egyptian pyramids for history to judge us, for it will take thousands of years for the forces of nature to erode them.

What payoffs can we expect from satisfying our innate curiosity to the tune of 20 billion dollars? Will the payoff be predominantly in the area of military security? Well, let us talk about the military aspects of space first. I think nobody in his right mind could say that outer space was not important for our national security. After all, intercontinental ballistic missiles fly through outer space today and the question our very survival in a global war would be directly affected by them. But that still doesn't answer the question, why we have to send people into outer space? Well, I would like to give you a quick summary on Project Mercury, NASA's phase of the manned space flight program. When this program was initiated, many people predicted that there was nothing in outer space that automatic equipment couldn't do a lot better than man. Man, they said, is just a liability. He is a nuisance. You have to keep him alive. On the other hand, he can't really contribute very much to space research, because he doesn't have the proper organs to sense and register the many interesting radiation phenomena in the space environment. So why bother about getting man up there?"

Well, let me tell you that in every single one of our Mercury flights, something went wrong, and in every single case it was the man in the loop, the astronaut in his capsule, who saved the day. It was the ability for the ground communicator to talk to him, to ask him, "what does your indicator show, the third one from the top on the right side of your instrument panel?" Or he would ask the astronaut to push a particular button to see whether he would get a certain response, or he would tell him "We have a failure in one of our command links. You try to do so and so and see whether it works." In every single case, it was the astronaut in the loop who saved the day.

It doesn't take much imagination to see that men in military space systems will put a new dimension in military space capabilities.

However, while this may be pretty obvious, it is not quite so easy to define the details of such a manned military space system. And the reason here is that we simply lack experience. The United States, as of this day, has logged a total of 53 hours of manned space flight. Compare this figure with the millions of hours that were logged in aviation, and you can easily see that the body of practical experience available in manned space flight is utterly inadequate.

If we want to learn how men can contribute to military space power, we must get men in outer space to gather practical experience. The modern concepts of air power were not developed by scientists and inventors brooding behind their desks. They were developed by Second Lieutenants and Ensigns who learned to fly back in those years, in 1905 and 1910, when the new ocean of air was first explored. It was these Second Lieutenants and these Ensigns who dreamed up schemes like synchronizing a machine gun with a propeller and use the airplane as a whole to aim the gun. It was these young, and brave and enthusiastic men who first tried their hand at formation flight, who took photographic pictures from airplanes to see whether the plane had any value as a reconnaissance tool, or who would drop wooden bombs into some staked out target to see whether they could hit anything. It was these young aviation pioneers who would first venture in the clouds with an airplane and who found out that you cannot fly in the clouds without proper instruments.

I think we have very much the same situation in outer space today. We have to get more men out there to do what John Glenn did, what Gordon Cooper did, and Schirra and Carpenter, and Shepard and Grissom. To learn to survive, to observe, to perform, to discipline themselves, to control their vehicles in this new environment of outer space. It is pointless to argue whether landing on the moon is the right national objective, whether we shouldn't concentrate on manned military space programs at this time rather than going to the moon. Only after we shall have logged thousands of hours of manned space flight, will we be able to define in detail what man can contribute to military space objectives. Now when you look in this context at those $20 billion that we are proposing to spend on our Saturn-Apollo lunar project , you will find that about 18 of those 20 billion dollars are really not spent on the lunar landing objective.

They are spent to develop the basic elements for manned space flight. What are these basic elements? They are big Saturn rockets that are needed to get man in outer space, they are the Apollo spacecraft that can maneuver in space, and whose heat protected capsules will enable astronauts to reenter the atmosphere at the end of their flight. They are the tremendous launch facilities at Cape Kennedy, Florida, where these Saturn-Apollo space ships will be launched. They are the huge static test stands where rocket stages and engines are tried before they are flown. They are the guidance laboratories, and assembly plants. But most important, they are the salaries of the 250, 000 people who are presently busy to develop our national space capability.

$18 of those $20 billion thus serve to develop a true, broad manned space flying capability. Only $2 billion are really spent specifically to land on the moon, but even the lunar landing craft has much broader utility.

But the military importance of outer space is only a small part of the story. The commercial applications are probably just as important. You have seen television from our Relay and Syncom satellites. 20 years from now most trans-Atlantic telephone calls will be made via communications satellites.

There will be global color television. Not only the kind of television that is transmitted to your local TV station, to which you have tuned your set, but television that you can receive from the satellite direct. This is very important, because it means that we will be able to directly reach any person on earth willing to tune his TV set to our satellite.

The power of this tool to communicate with the uncommitted people of this world should be enormous. The question whether such programs are sent in English, in Russian, or in Chinese may play a very important role in future world politics. Consider that only five years ago the first proposal to build a communications satellite was made, and you see that we are indeed living in a pretty fast moving age.

There are other commercial applications. Satellites will keep track of the weather. You have all seen the television pictures of cloud formations taken by TIROS, and Nimbus satellites. These satellites have television cameras looking down on earth, they are specifically designed to keep an eye on the weather, they show how storm fronts and hurricanes move. In conjunction with a high speed data transmission system between weather stations on earth and with buoys anchored out in the ocean which, at regular intervals, release baloons that give local weather data to the satellite passing overhead, this system is bound to vastly improve the art of weather forecasting.

The economical aspects of this again are likely to be quite sizeable, considering the fact that we are losing about $2 billion a year just in crop damage as a result of poor weather forecasts.

But again, I think this is not all. I believe the most important aspect of our space program is that we are bound to learn new things, that we will gather new insights into what makes the universe tick.

Professor Fred Whittle, who is the head of the Harvard Astronomical Observatory once said, "the trouble with astronomy is that so far all of our observations of the universe have been made through the dirty basement window of the atmosphere." In fact, there are only two relatively narrow windows in our electromagnetic spectrum for which the atmosphere is transparent. One of these windows is in the area of optical light and the other is a rather limited radio band. For all other portions of the electromagnetic spectrum our atmosphere is opaque. We are thus simply unable to receive, at the bottom of the atmospheric shell, most of the radiation emanating from the stars. All we know about the universe is based on what we know through the two narrow windows for which the atmosphere is transparent.

NASA is presently building some Orbiting Astronomical Observatories and some Orbiting Solar Observatories which are to keep track on the radiation in the rest of the electromagnetic spectrum that emanates from the sun, and the stars. We are likely to learn a great deal out of these observations.

How will these studies help the man-in-the-street? Well, I think I should like to give you a little example of the curious and strange relationship between science and practical application. About 80 years ago, some astro-physicists began to wonder what kept the sun hot. They figured that the sun was losing energy at the incredible rate of 10^{23}. Now that is a 1 with 23 zeros in a kilowatt is approximately a horsepower. The sun was radiating this tremendous rate of energy out into the universe and yet there was no indication that the sun was cooling off. Simple calculations indicated that even in 200 years or so that solar observations have been conducted and there should be a very noticeable decrease in solar temperature unless the sun had some ways and means of replenishing this energy loss. What was the mechanism to replenish these losses? Well, one fine day an astronomer observing the spectrum of the sun thought he had made a new discovery and he announced the discovery of the new element that he called helium. Then a theory was developed that maybe helium, the mysterious new element unknown on earth, was formed inside the sun by the fusion of the lighter hydrogen atoms that make up the bulk of the mass of the sun.

The theory went something like this. The sun had this tremendous gravitational field that kept all the planets orbiting including the earth, and way down toward the center of the sun, there must be pressures as a result of the gravity of many millions of atmospheres. At the same time, as a result of compression, there must be temperatures in the order of several hundred million degrees. Now under these conditions, the atoms the new theory said, were whirling about each other at such rapid speeds according to the high velocity, and at the same time, they were so densely packed due to high pressures, that the probability of some atoms hitting each other with tremendous speeds and fusing together was quite great. This process, a theory of nuclear physics had indicated, would release tremendous energies, and someone at that time coined the word thermo-nuclear energy. Nevertheless, it seemed entirely obvious and clear that thermo-nuclear energy could only be released under these unearthly conditions in the center of the sun. You know what happened when these unearthly conditions were finally duplicated on earth. A whole island in the Pacific disappeared when the first hydrogen bomb was exploded. (Ad lib: Electricity by fusion, plasma generator) I, for one, am convinced that most of you will still see the day when the price of the kilowatt hour will drop to maybe 1/10 of what it is today. When we learn how to convert sea water by the construction of heavy water by a thermo-nuclear reaction into electricity. Now the price of the kilowatt hour, the electric rate, is probably the most important yardstick for the standard of living of any country because it indicates the number of electrical slaves, as it were, that you can afford to have working for you. I mean those electrical slaves that heat or cool your house, drive the kitchen range, the washing machine and the ice box and maybe one fine day even power your automobile. So, with the price of electricity going down, the standard of living of mankind is about to climb up, and very effectively so.

(Here: Renaissance)

Now what can we learn from all this? We can learn that the search for knowledge somehow pays off, but we can also learn that it is well-nigh impossible to predict what will follow in the wake of a great discovery. I think 80 years ago those astronomers who were wondering what kept the sun hot, would only have shaken their heads had anyone told them that one fine day as a direct result of their discoveries man will build the most terrifying weapon ever invented; namely, the hydrogen bomb, and that again in the wake of this bomb development, man will find a bonanza enabling him to drastically reduce the price of electric power. I think we might as well realize that our crystal ball isn't good enough to say what the important payoff of a new major discovery will be. But at the same time we have ample proof today that somehow it does pay off to understand the universe a little better.

And this, ladies and gentlemen, is why I think we have an agressive space program today.

We have crossed the threshold of space. We are busily observing the phenomena of this new environment. But no one can say at this time how we can best use this new knowledge to our advantage.

Neither can the onslaught against the mysteries of space be slowed or halted. Our science and technology, particularly the science of rocketry, has developed to the point where the exploration of space is the next logical step in its advance. The true destiny of rocketry is the exploration of space for peaceful purposes -- not the delivery of atomic bombs for man's destruction.

I firmly believe that we shall go on after Project Apollo is completed to explore the solar system. If we are to capture the reality of space, come to know it, and really use it, we must expose more people to space travel, for extended periods of time, and then apply what these people learn first hand in their new environment. The Mercury astronauts were our first scouts into space. We are still very much in the first stages of exploration and discovery.

Our position today brings to my mind an earlier period in the history of the Western World, the period when man first laid the great foundation, both in thought and achievement, for the better world we enjoy today. I speak of the Renaissance, the era of Michelangelo, da Vinci, and Shakespeare. It was this period, beginning in the Fourteenth Century, that man took terrific strides to emancipate himself from his environment. In this period he undertook in earnest the conquest of his home planet as a place of human habitat. This was the age when men summoned their courage and set out on the high seas to explore the earth. It was the age of Columbus, de Gama, Sir Francis Drake, and Magellan.

The Renaissance is often called the age of discovery. I believe we are entering the second great age of discovery, the exploration of outer space. To take part in that exploration is to take part in history during one of its great forward leaps.

Let me quote a statement about America's future in space, made by the late President John F. Kennedy:

"Many weeks and months and years of long, hard tedious work lie ahead. There will be set backs and frustrations and disappointments. There will be pressures for our country to do less and temptations to do something else. But this research must and will go on. The conquest of space must and will go ahead...

"Frank O'Connor, the Irish writer, tells in one of his books how he and his boyhood friends would make their way across the countryside; and when they came to an orchard wall that seemed too high to climb, too doubtful to try, too difficult to permit their journey to continue, they took off their caps and tossed them over the wall -- and then they had no choice but to follow them.

"My friends," the President continued, "This nation has tossed its cap over the wall of space -- and we have no choice but to follow it. Whatever the difficulties, they must be overcome. Whatever the hazards, they must be guarded against... With the help and support of all Americans, we will climb this wall with both safety and speed -- and we shall then explore all the wonders and treasures that lie on the other side."

NOW: SLIDES

TURN LEFT LAMP OFF!!

SLIDE 1 -- U. S. Launch Vehicles (MS-G 67-27-62 Rev. E, June 1, 1964)

In the "line-up" of U. S. launch vehicles, an idea of the vehicle power required for the moon trip becomes apparent. The Saturn V moon rocket dwarfs all other launch vehicles. Also, for comparison you can see here the Thor-Agena, number three, and the Atlas-Agena, number five.

At the Marshall Space Flight Center at Huntsville, we are responsible for the three Saturns -- Saturn I, Saturn IB, and Saturn V.

The Saturn V will be able to orbit a payload equal in weight to 80 Mercury spacecrafts like the one flown by John Glenn and the other astronauts. The Saturn V will hurl 45 tons to the moon, or send 35 tons to Mars or Venus. And we are studying plans for still larger space launch vehicles -- Lake Erie size.

SLIDE 2 -- Static Test (PIO/VII B2A (1))

Saturn I boosters, powered by a cluster of eight H-1 engines, undergo two or three hot performance tests at the Marshall Center. The stages' engines fire into a "bucket" or deflector plate at the base of the tower. The bucket is cooled with 40,000 gallons of water a minute, making the flames literally ride on a cushion of steam. During each static test we record some 1,000 channels of information and if everything is found to be okay during a check afterwards in our Quality and Reliability Assurance Laboratory, we certify the booster stage for shipment to the Cape.

SLIDE 3 -- H-1 Engine Final Assembly (M63-495)

Here is one of the engines -- the H-1 -- that drive the Saturn I first stage. Developed by the Rocketdyne Division of North American Aviation, the engine burns kerosene and liquid oxygen. The nozzle is cooled by the kerosene which first flows through the cooling jacket before it is admitted into the injector chamber. The liquid oxygen is pumped directly into the injector. Each engine produced 188,000 pounds thrust, making the total thrust of the Saturn I booster one and one-half million pounds.

SLIDE 4 -- Saturn I Launch

Seven Saturn I rockets have been launched to date and each one in the test series has performed perfectly. The last three vehicles, SA-5, SA-6, and SA-7, flew with live second stages. Each placed more than 37,000 pounds into orbit -- 40 per cent greater than any announced Russian payload. They also vindicated our liquid hydrogen/liquid oxygen approach for upper stage propulsion. All Saturn rocket upper stages will be powered by engines using the exotic fuel -- liquid hydrogen -- a pretty unusual liquid in that it has a temperature of -423 degrees Fahrenheit. The Saturn I second stage clusters six RL-10 Pratt and Whitney engines using liquid oxygen. Each produces a thrust of 15,000 pounds for a total thrust in the second stage of 90,000 pounds.

SLIDE 5 -- Saturn IB Hardware at Michoud

After the Saturn I launch series is completed next year, the Saturn IB will be next up at the plate. The Saturn IB booster is essentially the same as the Saturn I, except that the eight H-1 engines are up-rated in thrust to 200,000 pounds each for a total booster thrust of 1.6 million pounds thrust. Here we see a booster taking shape at the Michoud Facility in New Orleans. And the booster stage has been refined to take several thousand pounds from the total weight. The Saturn IB second stage is almost identical to the third stage of the Saturn V, the big moon rocket. It has a single J-2 engine producing 200,000 pounds thrust. The J-2 is also a liquid hydrogen burner. The Saturn IB will be the first Saturn to launch an astronaut in an Apollo spacecraft for checking it out in earth orbit before its eventual flight to the moon.

SLIDE 6 -- J-2 Engine (MS-G-48-9-63)

Here is the J-2 engine which powers the second stage of Saturn IB. The contractor, again is Rocketdyne. And the J-2 burns liquid hydrogen/ Liquid oxygen just like the six smaller engines in the Saturn I second stage. The J-2 is actually used in three separate Saturn stages: First here in Saturn IB, then in a cluster of five to power the second stage of Saturn V, and again in the third stage of Saturn V.

SLIDE 7 -- S-IC Mock-Up (4-9417)

You have heard a great deal about the Saturn V, so here it is. But, this is only the first stage, which is being developed jointly by the Marshall Center and the Boeing Company. This first stage has a diameter of 33 feet and is powered by five F-1 engines, each of which has as much thrust as all eight engines of the "baby" Saturn I. Here, you see a mock-up which is being produced by Boeing at Michoud in New Orleans. One of the five F-1 engines is in place in the boattail. Total thrust of this stage reaches seven and one-half million pounds. Take-off weight of the entire Saturn V vehicle is six million pounds, about equal to 25 fully loaded Boeing 707's.

SLIDE 8 -- F-1 Engine in Stand (M61-2688)

The F-1 engine which will power the Saturn V booster has been undergoing static tests at the Marshall Center for quite some time. Our most powerful engine in an advanced stage of development, it burns kerosene and liquid oxygen. The turbo-pump alone, which feeds the propellants into the thrust chamber, has 55,000 horsepower. Studies are presently underway to uprate the F-1 for even larger orbital and earth-escape payloads.

SLIDE 9 -- S-II Stage Bulkheads (4-9545)

The second stage (S-II) for the giant Saturn V is taking shape at this fabrication plant at Seal Beach, California, a facility of North American Aviation's Space Division. These are propellant bulkheads for the hydrogen-fueled stage, which clusters five J-2 engines. The S-II stage is 33 feet in diameter and 82 feet long. Propellant capacity of this stage is 930,000 pounds.

SLIDE 10 -- S-IVB Cutaway (MS-G-13-62 Rev. A)

When the second stage of the Saturn V burns out and is separated, the remaining units will be almost, but not quite, in orbit around the earth. Injection into the desired orbit will be attained as the S-IVB or third stage, is ignited and burns for about two minutes. This Saturn V third stage is unique in that it is a stage of the launch vehicle and at the same time remains linked physically to the Apollo spacecraft after earth orbit. The stage is restarted during earth orbit to propel itself and the spacecraft into the proper trajectory toward the moon. Only after the repositioning by the spacecraft is completed, is the S-IVB finally jettisoned.

SLIDE 11 -- VAB (LOC 63C-3609)

Soon to be the tallest building in Florida is this vertical assembly building which will be used to assemble and check-out Saturn V's prior to launch at Cape Kennedy. In actual volume, this building will be the largest in the world. When completed in mid-1966 the cost will be about $100 million dollars and it will be a key part of Launch Complex 39 from which lunar-bound astronauts will be launched. Construction of the building is a joint venture by several contractors.

Slide 12--Saturn V on Pad (MS-G-113-62)

Ready for launch, the Saturn V will be carried to the launch pad from the vertical assembly building on a crawler which runs on caterpillar tracks and ispowered by a 5,000-horsepower diesel system. The rocket is fueled after reaching the pad. There are elevators going up through the umbilical tower and various critical stations of the rocket are accessable through gang-ways. The astronauts will board the spacecraft over one of these gang-ways. You might say that they will walk the plank before reaching the spacecraft in the vehicle's nose.

Slide 13--Apollo Spacecraft (MS-G-91-62)

There are three main elements or modules in the Apollo spacecraft. The Saturn IB can carry this spacecraft into earth orbit, but it requires the Saturn V to launch the same equipment, including the necessary propellants and life-sustaining systems, for a trip to the moon and back.

The nose of the craft is the command module, actually the flight deck of the spaceship, you might say. The three astronauts will ride here during powered phases of the launch. It is equivalent to the well-known Mercury capsule, only there is room for three men and the cabin itself is roomy enough for two more men for near-earth operations.

Underneath the command module is the service module which has as its essential element a restartable rocket engine used to perform many critical maneuvers including the deboost of the rocket into an orbit around the moon and back out of this orbit into the proper course on the return to earth.

Finally, and probably most important, is the lunar excursion module, or bug. This is the actual vehicle that will touch down on the surface of the moon. Its two main elements consist of a landing stage for the moon landing and an upper stage in which the men return to moon orbit and rendezvous with the command module.

Slide 14--Boarding Spacecraft (4-2056-C)

The big moment has come and the astronauts have walked the plank and are preparing to board their capsule. The men are entering through the hatch of the command module and are settling down in the contour couches with assistance from some pad workers who will, of course, return to the blockhouse prior to launch. Also visible is the escape tower which has very much the same function as the escape seat in a jet. Powerful high G rockets can jerk the entire command module away from the launch vehicle in case of trouble during the early minutes of the launch.

Slide 15--Blockhouse Scene (4-2064-C)

While the astronauts tick off the last hours of the countdown in the confines of the command module, a large crew has assembled in the blockhouse to handle the complicated launch operations. Here are the men who actually launch the rocket. They monitor all phases, both of the rocket and tracking stations, down to the last minute to make sure that everything is in good working order. They also maintain contact with the astronauts onboard the rocket and both sides must reach agreement before the "go" order is given.

Slide 16--Saturn V Launch (4-2059-C)

The Saturn V with its payload of three astronauts is off and on the way to the first trip to the moon. Some people doubt the wisdom of riding in rockets, which reminds me of the story of two caterpillars crawling along in the grass. One said to the other: "See that butterfly fluttering overhead? You'll never get me up in one of those things." This scene shows the rocket about 10 seconds after ignition.

Slide 17--First Stage Separation (4-2061-C)

After about two and one-half minutes, the first stage has burned up its propellants and is discarded. Here, it is shown dropping away and the five J-2 engines, burning hydrogen and oxygen, ignite in the second stage. The vehicle flies for about six minutes under the power of the second stage, which drives the ship up to approximately 80 per cent of orbital speed.

Slide 18--Second Stage Separation (4-2062-C)

Here we see the second stage being discarded and ignition of the third stage. Retrorockets kick the second stage back and it falls into the atmosphere from this altitude of about 100 miles. The single engine of the third stage ignites, providing a relatively short burn period, but enough to attain the desired earth orbital speed.

Slide 19--Parking Orbit (4-2065-C)

After the third stage shutdown, the vehicle is in a parking orbit about 100 miles above the earth. The parking orbit is, more or less, a matter of operational convenience where everybody can catch their breaths and run quick rechecks of all systems. While we can launch the vehicle into earth orbit at any time we choose, the injection to the moon has to be scheduled inflexibly for a certain time frame. Therefore, the parking orbit can be lengthened or shortened according to the necessary timing required for injection into moon trajectory.

About 98 per cent of the re-check of equipment is handled from the ground and the astronauts are given a last assurance that their ship is ready in all aspects to go deeper into space.

Slide 20--Injection (4-2066-C)

A countdown is begun during the parking orbit and the third stage is ignited again to speed the vehicle in a tangential direction away from earth. During this second ignition, the third stage burns for over six minutes to build up the desired earth escape speed of 25,000 miles per hour. The astronauts are now on their way to the moon.

Slide 21--Begin Docking Maneuver (4-2068-C)

After injection into the proper path toward the moon, four adapter shells are blasted away to reveal the lunar excursion module. Auxiliary propulsion engines drive the combined command and service modules a short distance from the third stage of the Saturn V. The forward tip, or protective shroud, no longer needed, is thrown away to save mass.

Slide 22--Docking Maneuver Completed (4-2071-C)

Shortly after separation, attitude control nozzles on the command module are used to turn the combined command and service modules around in a complete 180 degree turn. The command module drives its nose into the docking cone of the bug, or lunar excursion module, and pulls the bug away from the burned out third stage of the Saturn V. Although the units are traveling at 25,000 miles per hour, the relative speed between the units is virtually zero. The astronauts aren't even aware of the speed at which they are moving since there are no telephone posts zipping by outside their window. They are now ready to check highway maps to see if they have taken the correct routes.

Slide 23--Mid-course Calculations (4-2087-C)

No further power applications are necessary in the flight, provided the spacecraft is in the correct groove. Since the moon is 238,000 miles away, the injection might not have been quite precise and a mid-course correction maneuver may be necessary. Here, the astronaut is looking into a navigational device which automatically computes his position and also any correction maneuver which may be necessary to put the craft into the proper groove.

Slide 24--Mid-course Correction (4-2073-C)

If the astronauts determine that a change is needed in their trajectory, the service module engine may be fired to make the necessary corrections. The correction maneuver can be repeated a second or third time, as the need may occur.

Slide 25--Entering Lunar Orbit (MS-G-37-10-63)

As the spacecraft approaches the moon, the service module engine is fired again. It decelerates the unit so that the speed is reduced by something like 3,000 feet per second to place the craft into a moon orbit.

Slide 26--Transfer to LEM (NASA M63-466)

While in lunar orbit, two of the three astronauts transfer through a crawl tunnel to the flight deck of the bug, or lunar excursion module. The third man remains with the command and service modules. He is the storekeeper and will stay in orbit around the moon until his two companions return. He acts as observer throughout the actual moon landing and keeps in constant communication with the earth.

Slide 27--LEM Separation (4-2074-C)

After entering the lunar excursion module, the two astronauts detach the craft from the command and service modules and enter an orbit which brings them much closer to the moon's surface. As the bug is decelerated, moon gravitation pulls it down. The astronauts at this point can locate the best portion of the previously selected landing site.

Slide 28--LEM Touchdown (4-2075-C)

The lunar excursion module approaches the lunar surface with the retarding engine decelerating the craft. The throttleable rocket engine is adjusted to a thrust level where the unit simply hovers above the moon like a helicopter. Looking out the windows, the astronauts observe the lunar surface for local obstacles. If necessary, the craft at this point can move laterally to a desired point. While hovering, should the astronauts find that the area selected is absolutely impossible to land on, or that the moon is green cheese after all, they can still gun the engine and, without touching down on the moon surface, go back to lunar orbit and rendezvous with the third man in the command module.

Slide 29--On Moon Surface (4-2076-C)

After a successful landing and checkout of the craft to assure that it will fly again, the astronauts lower their face plates and depressurize the flight deck of their landing craft. One of the astronauts disembarks through one of the docking doors and sets foot on the lunar surface. His companion will monitor him, very closely at first. After a few hours, the astronaut will return and the other astronaut will go out. At no time will both astronauts be outside the craft at the same time.

This first moon trip, understandably, will be scientifically limited and designed primarily to accomplish survival and landing and docking techniques. Apollo follow-on programs provide for lunar bases and shelters where the astronauts can get out of their pressure suits, sleep, eat and do some scientific work.

Slide 30--Moon Exploration (4-2079-C)

Here you see one of the two men venturing out a little bit. He probably has just picked up some rocks and perhaps talked to some of the little green men who live on the other side of this moon mountain, and he is now returning to his spacecraft to relieve the other man.

Slide 31--Blast Off From Moon (4-2080-C)

Within 24 hours after landing, the two astronauts will prepare for the homeward journey. They board the same flight deck in the lunar craft. The landing stage of the bug has completed its mission and is used as a launch pad for the return stage. A countdown is performed and the upper LEM stage is launched. Attitude control throughout the maneuver is provided by small auxiliary jets which create a few pounds of thrust and can be pulsed.

Slide 32--Lunar Orbit Rendezvous (MS-G-37-17-63)

Entering moon orbit again, the bug flies into an increasingly slanted flight path where the combined command and service modules and the storekeeper are waiting. The moon departure must be properly timed to make the rendezvous possible. It is not a catastrophy if they miss the rendezvous point since the orbits can be adjusted so that the units will catch up with each other. Computers in the spacecraft and on earth define departure times and nail down the rendezvous. On board radar measures line of sight, direction and closing rates--or relative speed at which the two units are approaching one another.

Slide 33--Rendezvous (4-2081-C)

In addition to radar and computers, the rendezvous maneuver is executed visually--looking out windows--by the astronauts in the bug and the storekeeper in the command module. Here you see how the maneuver will look to the two returning moon astronauts. Both units have maneuvering capabilities and several modes are possible to complete this docking.

Slide 34--Return To Command Module (4-2083-C)

Here, the docking has been completed, and the two astronauts crawl back through the tunnel, join their companion in the command module, and detach the return stage of the bug. This remaining stage of the bug is abandoned in orbit around the moon.

Slide 35--Leaving Lunar Orbit (4-2084-C)

At the proper moment, the service module is fired up again to propel the craft out of the gravitational field of the moon to the point where the gravitational field of the earth becomes stronger. From then on, gravity accelerates the unit and it falls like a stone toward the center of the earth. The unpowered flight back to earth takes about 70 hours. Again, mid-course maneuvers are possible to nail down the proper approach.

Slide 36--Reentry Corridor(M62-134)

There is a narrow corridor available in which earth reentry is permissable. If the approach is too steep, the deceleration encountered by the increasing aerodynamic drag may crush the astronauts and the capsule may even be burned up by overheating. If the approach is too high, the unit may skip out of the atmosphere again, like a stone skipping across a mill pond.

The importance of high precision at this point is obvious. However, we believe we can nail this approach down very precisely with earth ground support. In many respects, this reentry approach is similar to an instrument landing on earth.

Slide 37--Command Module Separation (4-2086-C)

Prior to reentry, the command module containing the three astronauts is separated from the service module. The service module falls into the atmosphere and is burned up. However, the command module is heat protected so well that a temperature change of only one to two degrees is expected inside the craft.

The command module is flying with point end forward. It has to be turned around so as to enter the atmosphere with the blunt end forward, just as the Mercury capsules did. This turnaround is accomplished with attitude control nozzles.

Slide 38--Reentry (4-2089-C)

Here, the command module is reentering the earth's atmosphere, with the blunt end forward. Actually, the unit is tilted at an angle of attack of 30 degrees, blunt end forward, which creates drag and lift. The direction of the capsule can be changed through control of the lift vectors, all done automatically. Because of this tremendous flexibility, we believe we can land the capsule within ten miles of the intended target area.

Slide 39--Chutes Deployed (4-2091-C)

At 30,000 feet, a small drogue chute is deployed. It further decelerates the craft and also stabilizes its descent. At 10,000 to 12,000 feet, the drogue chutes pull out the three main parachutes. They are deployed so as to open a little at a time and avoid the shock of an ordinary quick-opening parachute. The command module has built-in shock absorbers so that landing on land is permissable. At the same time, the capsule floats, giving the option of landing on land or water.

Slide 40--Earth Landing (4-2092-C)

While the astronauts will probably prefer to land on water, circumstances may call for touchdown on land. Here we see the moment of the landing as it would occur on dry land. All the men have to do is open the door and get out. Some people say that the real challenge of the voyage is only now beginning--the press conference.