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**NEWS**

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**NEWS BRIEFING**

**ON**

**APOLLO 8 MOON ORBITAL FLIGHT**

**PARTICIPANTS:**

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**LT. GENERAL SAMUEL C. PHILLIPS, Apollo Program  
Director, NASA**

**MR. WILLIAM C. SCHNEIDER, Apollo Mission Director, NASA**

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ALIBRANDO: Good morning. We are ready to begin the press conference on the Apollo 8 decision.

The participants this morning will be Dr. Thomas Paine, Acting Administrator; Lt. General Samuel Phillips, Apollo Program Director; and Bill Schneider, Apollo Mission Director.

Dr. Paine.

PAINE: Good morning. After a careful and thorough examination of all of the systems and risks involved, we have concluded that we are now ready to fly the most advanced mission for our Apollo 8 launch in December, the orbit around the moon.

Frank Borman and his crew and all of our engineers are unanimously in favor of selecting this mission.

We have reached this conclusion after a long series of intensive investigations of the status of our program, the flight hardware, ground support equipment, status of our training.

The timing for the December 21 launch is conditioned by the position of the earth and the moon and the sun. It is designed to give us daylight in the launch area and the recovery area and then designed to give us the right kind of photographic and observation light on the surface of the moon.

The outbound trip will occupy about three days, the time in orbit around the moon will be about a day involving ten orbital swings around the moon, with about a three-day return, actually adding up to something just slightly over six days to the recovery.

To tell you about the details of this decision and the mission, I would like now to introduce the Director of our Apollo Program, General Samuel Phillips.

PHILLIPS: Good morning, ladies and gentlemen. The mission that we have decided to fly with Apollo 8 is the mission for which the Saturn V was designed. And insofar as the Saturn V is concerned, it won't know the difference between this mission and a lunar landing mission.

And it's also in most important respects the mission for which the Apollo spacecraft was designed.

The exception in the case of the Apollo spacecraft, of course, is that there is not a lunar module aboard, and the command and service modules will make the trip to the moon without having the LM docked, and that's the exception.

But in most important respects in terms of the knowledge we will gain, it is the design mission for the Apollo-Saturn V space system.

Now, we have concluded, as Dr. Paine has said, that the total Apollo space system will be ready for that mission at the scheduled launch time on the 21st of December.

I would like to take some time this morning to summarize the important elements of the background that led us to that decision and to discuss also the basis of our conclusion.

Let me start with November a year ago when we flew Apollo 4, which consisted of the 501, Saturn V launch vehicle, and the 017 spacecraft. That mission, as you will recall, being the first Saturn V flight, was a perfect mission, a flawless mission. The launch vehicle demonstrated completely all of the maneuvers and performance and operations required for the ultimate lunar landing mission.

As far as the launch vehicle knew, it was carrying out its design mission.

The spacecraft 017 flew for nearly 11 hours, under on-board program control and under remote control from the ground, and performed flawlessly. Among its many demonstrations, it demonstrated the high-speed reentry that is required for the return from a lunar mission.

Now, you can draw many conclusions from that mission, but one of them is that it showed that the Apollo-Saturn V design is a good design.

Now, in April of this year we flew the second Saturn V, No. 502, which carried the spacecraft 020, the

sister ship of 017. We called it Apollo 6. It was designed in most important respects as a repeat of the Apollo 4 mission.

There were on that mission several important technical failures and malfunctions. You will recall that during the second-stage operation two engines failed. During the orbital coast and the preparation for restart for the simulated translunar injection, the upper stage failed to restart for the translunar injection.

In the post-mission analysis we determined that we had longitudinal oscillations on that vehicle which are commonly called POGO. We observed also there was abnormal performance of the propellant utilization system which controlled the division of fuel and oxidizer in the engine during the propulsive maneuver.

We also discussed in the briefing that followed that mission an apparent structural failure in the spacecraft LM adapter area of the structure. We also observed at that time, I will recall again, that in spite of these difficulties, which were substantial and important, the spacecraft was commanded off into an alternate mission by the flight control organization and it flew a flawless alternate mission, re-entering in the Pacific as intended.

Now, the question that one can raise then from this series 501 and 502 really concerns the total adequacy of the design and of the processes of manufacture and therefore of the margins that are available in a piece of equipment.

After that mission we very rapidly assessed the technical data, determined by the latter part of April of this year that we understood sufficiently the reason for the malfunctions that occurred, that we felt we could proceed with confidence to prepare the next Saturn V, No. 503, to carry out a manned flight in the latter part of this calendar year.

Since that time there has been one of the most aggressive, thorough and determined engineering tests and engineering analysis programs conducted that I have ever seen. And in the course of these months we have identified



in detail the reasons for the difficulties. We have designed the corrections. We have tested at great length the corrections and, in parallel with all this, conducted a very elaborate engineering analysis.

This culminated week before last on the 7th of November in a design certification review which concluded by validating and certifying the Saturn V No. 503 as ready for manned flight.

Let me recall also that last August in a press conference and briefing that we had on the 19th of August, to be specific, I outlined the events that led us to the decision to drop LM 3 from the 503 flight which was being made ready for flight in the late part of this year. That decision was reached because we were encountering delays in the checkout of the lunar module at the Cape which in our judgment was leading us to a flight well into the spring of next year if we were to wait until we resolved the difficulties that were delaying the checkout.

At that time we concluded that it was in the best interest of the progress of the program to prepare the 503 launch vehicle to fly with command service module 103 but without the LM in order to get the Apollo-Saturn V system into space operations at the earliest time and to make the gains toward our ultimate objective of a manned lunar landing by flying yet this year with a command service module only.

That decision then identified a range of alternative missions that we would prepare to conduct with the decision to be made after all of the program events had occurred, including the flight of Apollo 7, which would then be the basis for a decision to select from among those range of alternate missions, which included low earth orbit, high earth orbit, many thousands of miles in orbit, circumlunar or into lunar orbit and return as the range of options.

Now, Apollo 7, which of course flew between the 11th and 22nd of October, was launched on a Saturn-IB and carried the first Block II spacecraft, No. 101. That mission, as we all know, met its objectives, and I have classified it as a perfect mission.

We have since the mission took off been reducing the data from that flight. And, as you know, we carry many hundreds of instrumentation channels aboard each of our flights in order to be able to analyze the performance down several levels in all of the important subsystems. That analysis has been looking very hard at the question I asked after I mentioned the 501 and 502 sequence -- namely, at the design margins, possibilities of incipient failures which careful review of the details of the data might indicate, and a careful review of the performance of that spacecraft in its primary modes of operation such as the environmental control, where it was exercised thoroughly, as well as looking carefully at the performance in the several what I will call alternate or backoff or degraded modes of operation which we have built into this equipment through redundancy of design and by providing backdown features that the crew can select in case any of the pieces of equipment indicate abnormal performance.

As I say, we have concentrated many thousands of engineers' manhours in studying that data in order to assess and understand design margins and the possibilities of incipient failures. Because you recall, the way in which this program has been organized from the beginning, we have always known that we would never be able to demonstrate in a classical, statistical reliability sense the performance of the equipment and the reliability which requires tens or even hundreds of operations to demonstrate.

So we have based our program from the beginning on careful design, incorporating redundancies and degraded mode operation, and then a very, very extensive ground test program culminated by a minimum of flight demonstrations to validate the design.

Now, I'm going to discuss in a few moments two or three of the features of the work that has been done since that time using some vu-graphs, so I won't say any more about it right now.

Now, we in the Apollo Program have been working now for many years toward the objective of a manned lunar landing at the earliest practical and safe time. We concluded back in August and have devoted much energy to the point since that there is much to gain by going as deep into space with

the second manned Apollo flight as we would be able to judge prudent. We are able by going into lunar orbit to make an early flight demonstration of the design mission of the Saturn V and of the Apollo command and service module spacecraft and to understand the operation of the spacecraft in the thermal environment of translunar space and in the environment surrounding the moon, to assess our communications capability, and very importantly to evaluate and work on our navigation capability.

In this connection, our ability to identify and track landmarks on the lunar surface is very important to the precise orbit determination which we expect to be able to accomplish in order to with sufficient accuracy make the landing with the lunar module and then make the rendezvous between the lunar module and the command service module after the lunar landing.

We are also very aware of the gains that we can make by early development and evaluation of the procedures that are involved in the lunar mission, those concerned with flight control in our Mission Control Center as well as around the world, and, very importantly, our inflight procedures.

Now, while we have known and given much attention to the gains that can be made by proceeding out to lunar orbit, we have also recognized that in carrying out such a mission we take on some additional risks over and above those that one exposes himself to or the flight crew to operating in a low earth orbit. But we have been able to-- It is our conclusion that the progression of risks which we have known from the beginning that we have to undertake as we take on more and more of our complex system leading to the lunar landing-- We have judged that the progression of risk between the Apollo 7 mission which we have flown and the Apollo 8 mission which we have designed is a normal progression of risks in a logically stepped development, flight test program.

In the case of the lunar orbit mission, you can summarize these new risks in two categories. In the one category, the spacecraft propulsion system must operate properly in order to propel the spacecraft back out of lunar orbit and on its way back to earth. And the other category of risks are those that are inherent in being some three days away from the earth as opposed to somewhere between a half

an hour and three hours which the crew is away from the earth in a low earth orbital mission.

So in this case we have to place increased reliance on the dependability of the life support system and the electric power system in main.

Now, what I would like to do now is summarize for you using some vu-graphs some of the high points of the technical and operational reviews which have gone on day after day in great depth over the last several months to give you some feel for the depth of the consideration that has gone into this decision.

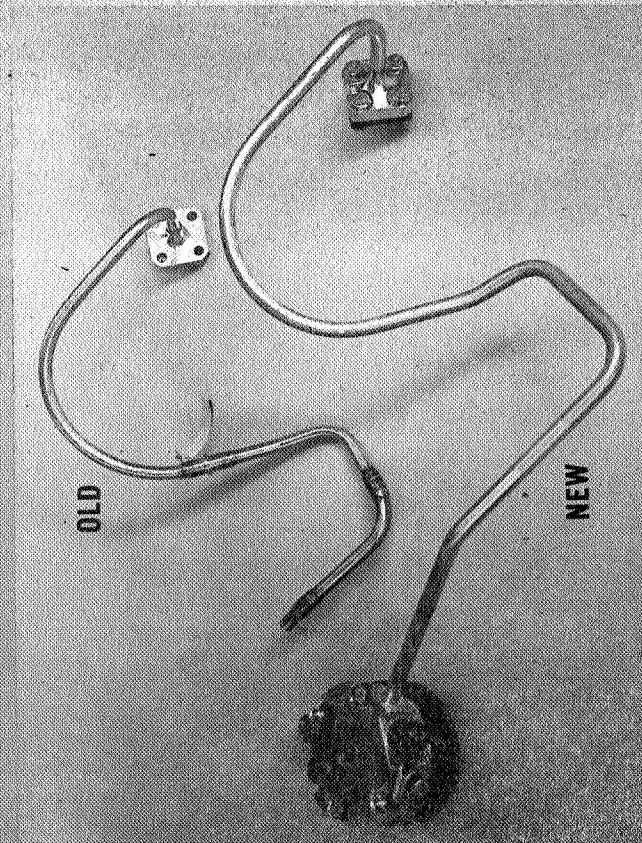
I'm going to just show two charts that concern the launch vehicle. And let me point out in that connection that the launch vehicle per se is really not involved in the decision process of whether we go into earth orbit or carry out a mission involving operations around the moon.

The decision that we just last week validated is the one which says that the Saturn V is indeed ready to conduct a manned flight. And the two most important technical failures on 502 were the failures of the J2 engine on the second and third stages and the longitudinal oscillation for POGO. What we did following that was to set up a test program in which we were able to very precisely reproduce the conditions of the failure on the engines, which came down to a failure of the small line which feeds hydrogen into the starter cup of the J2 engine.

This is the old line design and the weakness was in two flexible joints that were put there to absorb vibrations and the changes involved as the engine operated.

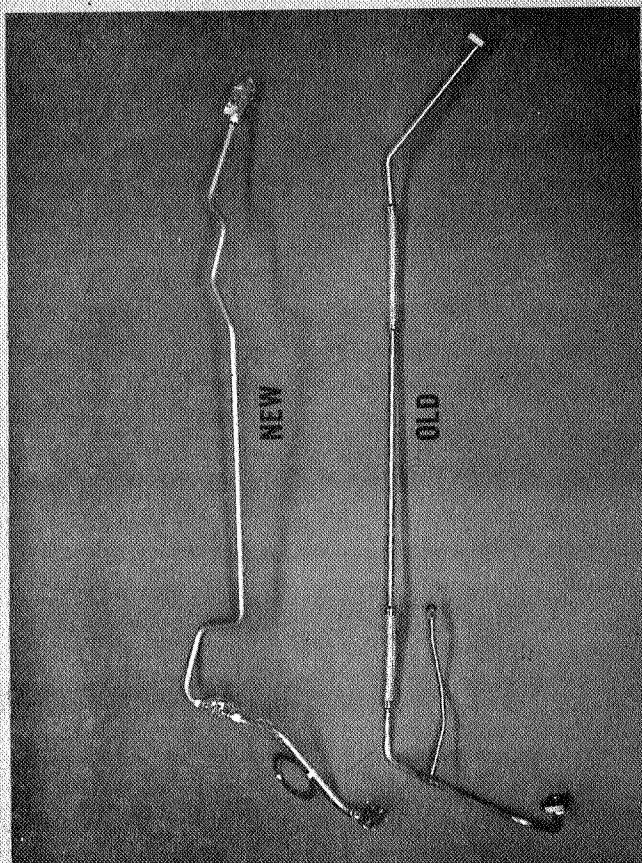
It took some fairly brilliant detective work to identify the fact that a flow vibration phenomenon was set up in these lines under dry vacuum conditions which had not been discovered in the ground testing, because in the final analysis it turned out that the ground test setup conducted in either ambient air conditions or in the blowdown type vacuum facilities in which one tests big engines allowed moisture from the air to freeze out on these flexible joints and to change the stiffness therefore the vibration characteristics.

# ASI LINES



**LIQUID OXYGEN OXIDIZER**

( $\frac{3}{8}$ " DIA.)



**LIQUID HYDROGEN FUEL**

(UPPER LINE  $\frac{1}{2}$ " DIA; LOWER LINE  $\frac{5}{8}$ " DIA.)



Operating in the vacuum of space, the moisture condensation on the extremely cold lines did not occur. The vibration characteristics were slightly different. The vibration caused cracking, and under the pressures involved in feeding hydrogen into this unit, these joints cracked and broke and resulted then in the failures of the engine and the failure of the restart of the S-IVB stage.

This line was redesigned and I might say over-designed in the process. The flexible joints were taken out, and bends in the tube were substituted to take up the motions. These were subjected to extensive overdesign testing, were verified as more than adequate to correct the problem.

The new design was also incorporated in the oxygen side of the engine start system, and it did fly on the S-IVB stage of launch vehicle 205 which propelled Apollo 7 into orbit.

So in addition to extensive ground testing, it has now been used once in manned flight.

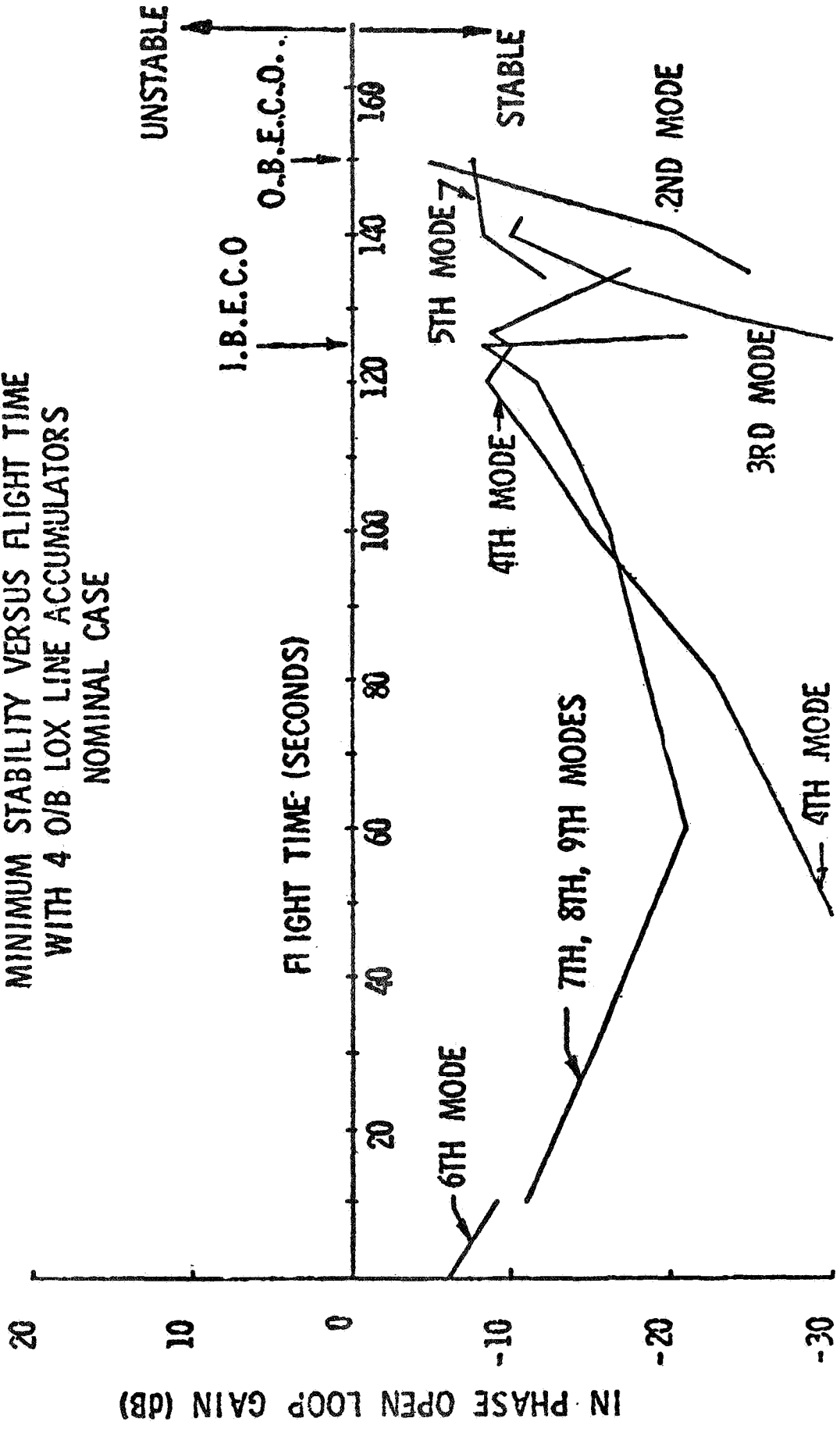
The next chart is a summary of the POGO situation in one of the important ways in which one measures the margins of the equipment. And this is one of the summaries which was used in the design certification review on the 7th of November to summarize several hours of technical discussion, and it is the result of many thousands of manhours of work involving many companies that we called on to help us.

The mode that got us into difficulty on 502 was the first longitudinal mode of the vehicle as it crossed the LOX line frequency which was up very close, and actually out around 90 seconds it became marginal as far as stability is concerned.

The correction that has been made is to use the pre-valve cavities of the LOX lines as accumulators, and we inject helium into those to provide a spring-like characteristic to the LOX column. And those accumulators are incorporated in the four outboard control engines on the first stage of the Saturn V.

And by so doing, the first mode that got us into trouble on 502 is completely off this chart. This ordinate is the loop gain in phase measured in decibels, and the criteria we have set for ourselves after the 502 flight was

AS-503 C' S-IC STAGE FLIGHT  
 MINIMUM STABILITY VERSUS FLIGHT TIME  
 WITH 4 O/B LOX LINE ACCUMULATORS  
 NOMINAL CASE



to achieve a stability margin of approximately 6 decibels.

Now, as I said, the mode that got us in trouble on 502 is completely off the chart. It is more than 30 db's of margin of stability.

And we plotted here all the higher modes up through the ninth mode. And here is the sixth, seventh, eighth and ninth tract along here. The fourth comes in here at this point. This is flight time in seconds.

And as the vehicle propellants deplete, the mode gains change. And you can see here that the third mode comes in late in the flight and then tailed off. And the second mode starts up right at the outboard engine cutoff. This was the shutdown of the stage. This symbol is where the Saturn engine cuts off, and at about 150 seconds the stage has finished its job.

So by combination of much testing that was accomplished in several facilities, a great deal of engineering analysis work, and finally system testing on S-IC test stage No. 6 and 7 in Mississippi, in which this design change was incorporated, we have concluded beyond doubt that we have a very adequate margin against POGO recurring on any subsequent flight.

Now, I recalled that one of our technical difficulties on the 502 flight was an apparent structural failure in the spacecraft LM adapter area of the structure. That subject too has received a great deal of test and analysis, and we have concluded beyond any doubt that the cause of-- We have concluded beyond doubt that there was a sheet of aluminum that peeled off, that that was one of the facing sheets of the bonded structure, that the reason it peeled off was because of an area on the outer facing sheet where the aluminum skin bond to the honeycomb was not adequate, an area of something equal to or greater than about ten square inches, and as the vehicle climbs into the upper atmosphere it is subjected to aerodynamic heating which raises the temperature, and, of course, it is subject to pressure change of the outside air. And we have concluded that moist air trapped in the honeycomb heated as it climbed, that there was a pressure rise inside the honeycomb as you measure it



to the outside ambient condition, that the pressure rise was sufficient to cause further debonding, which had started with a small debonded section, and enough debonding occurred then that the aerodynamic forces peeled off a sheet of aluminum.

You will recall that the structural margins of that design were adequate even so, that after some load relief occurred when the facing sheet peeled off, the structure re-balanced itself and the vehicle continued without subsequent failure.

I think that is one of the measures, incidentally, of design margins that we build in to the system in many ways.

Since that time, from a great deal of testing, we have now gone to an ultrasonic inspection of the honeycomb structure at the Cape, verifying that there are no debonded areas in that structure that are as big as one square inch, which is within the tolerance allowable. And in addition to that, we have drilled quite a number of holes on the inner facing sheet to vent the honeycomb. And in addition to that, we have put a thin layer of cork around the outer structure to minimize the temperature rise. So I think that that problem is more than corrected, and I won't say any more about it.

I would like now to go on to discuss a facet of the Apollo 7 mission that is critical and important in the decision we have made to carry out the lunar orbit mission. -- namely, getting to the margins with which we believe we have covered ourselves in our spacecraft systems.

The next chart.

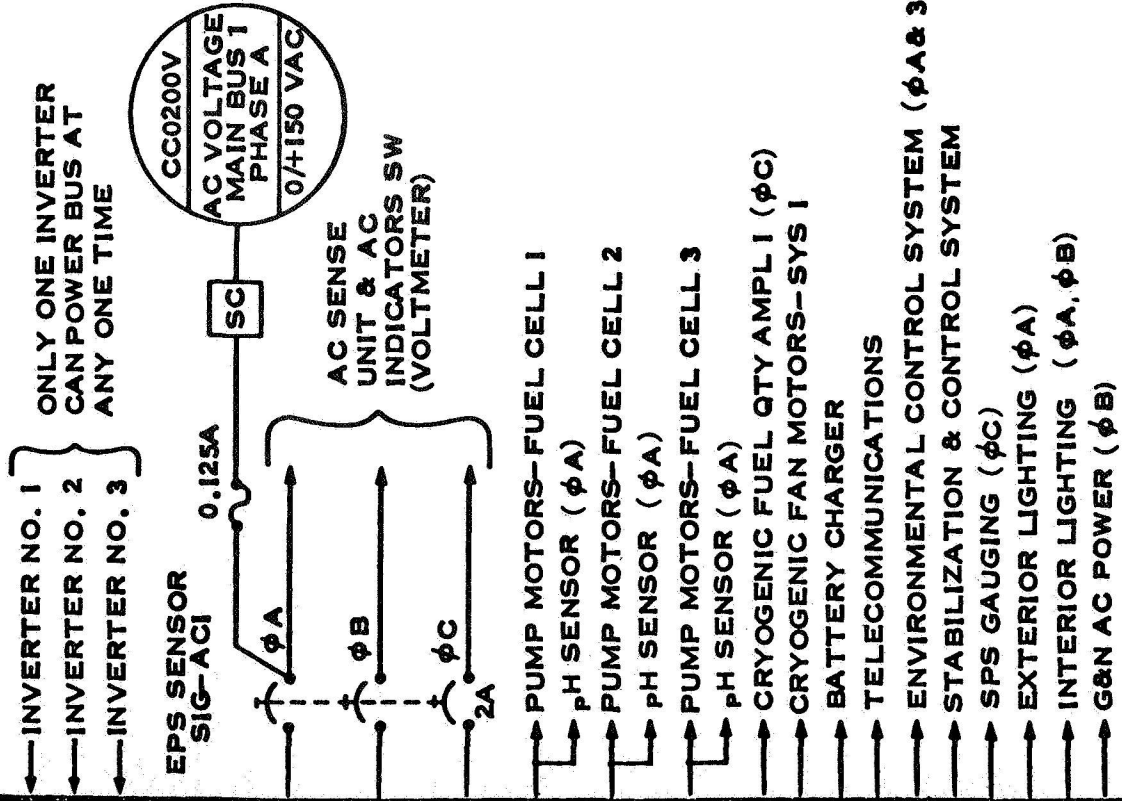
Many of you will recall that at three times during the Apollo 7 flight there were reports of AC bus dropouts. This occurred at something like 19 hours into the mission for the first time. Of those three incidents of AC bus failures, if you want to use that term, in two cases one bus dropped off or failed, and in one case both buses failed. In all three cases the crew was able to reset the breaker that had tripped, and the AC power came back on.

I will only point out that the way the spacecraft is designed there are two AC buses, bus No. 1 and bus No. 2.

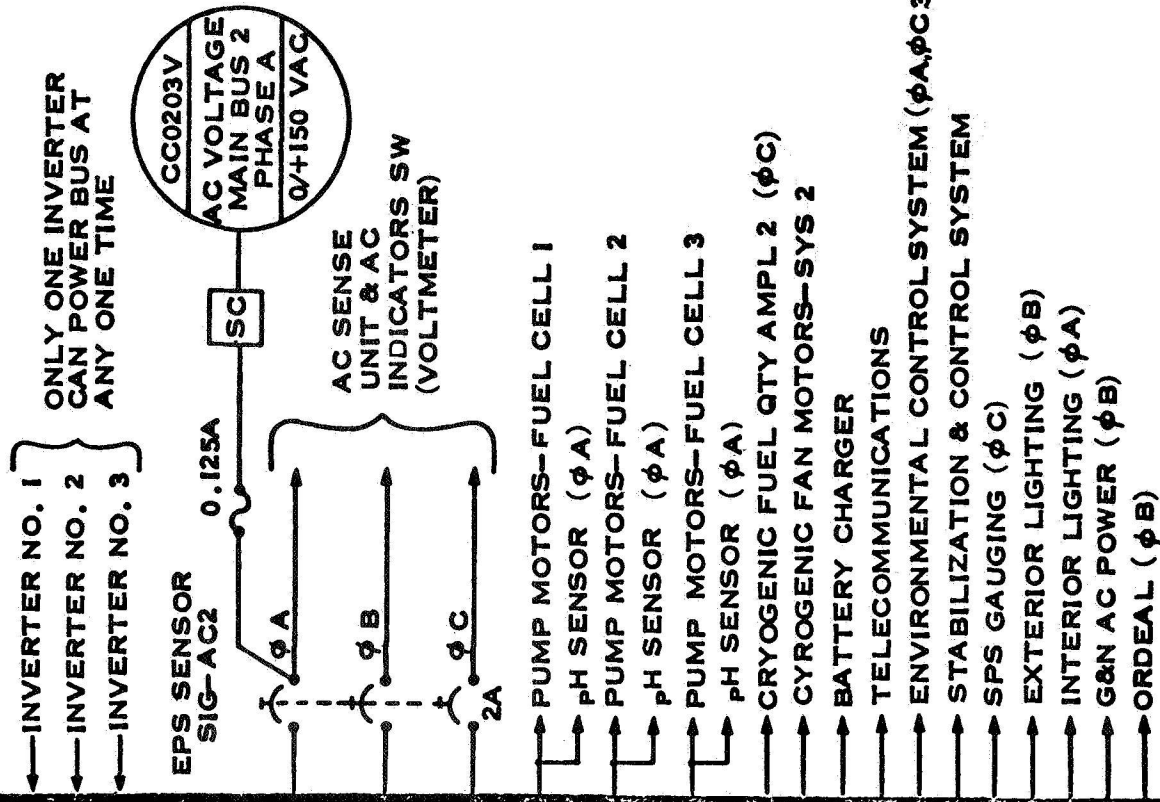
# ELECTRICAL POWER SYSTEM

## AC BUSES

AC BUS NO. 1



AC BUS NO. 2



There are three inverters, Nos. 1, 2 and 3.

Now, the inverters are driven from the DC bus, and their function is to convert 28-volt DC into three-phase 115-volt AC. Any one of the three inverters can be on either of the buses. The normal operation is to have one inverter on bus 1, another inverter on bus 2, and a third inverter off the line and in standby status.

These inverters power the rotating machinery of the spacecraft, and all of the systems that are powered are powered off of both buses. So you have got redundancy in terms of supply equipment from either bus and from any one of three inverters.

The spacecraft can be operated with only one bus and only one inverter, so you have got a three-mode degradation that is possible here.

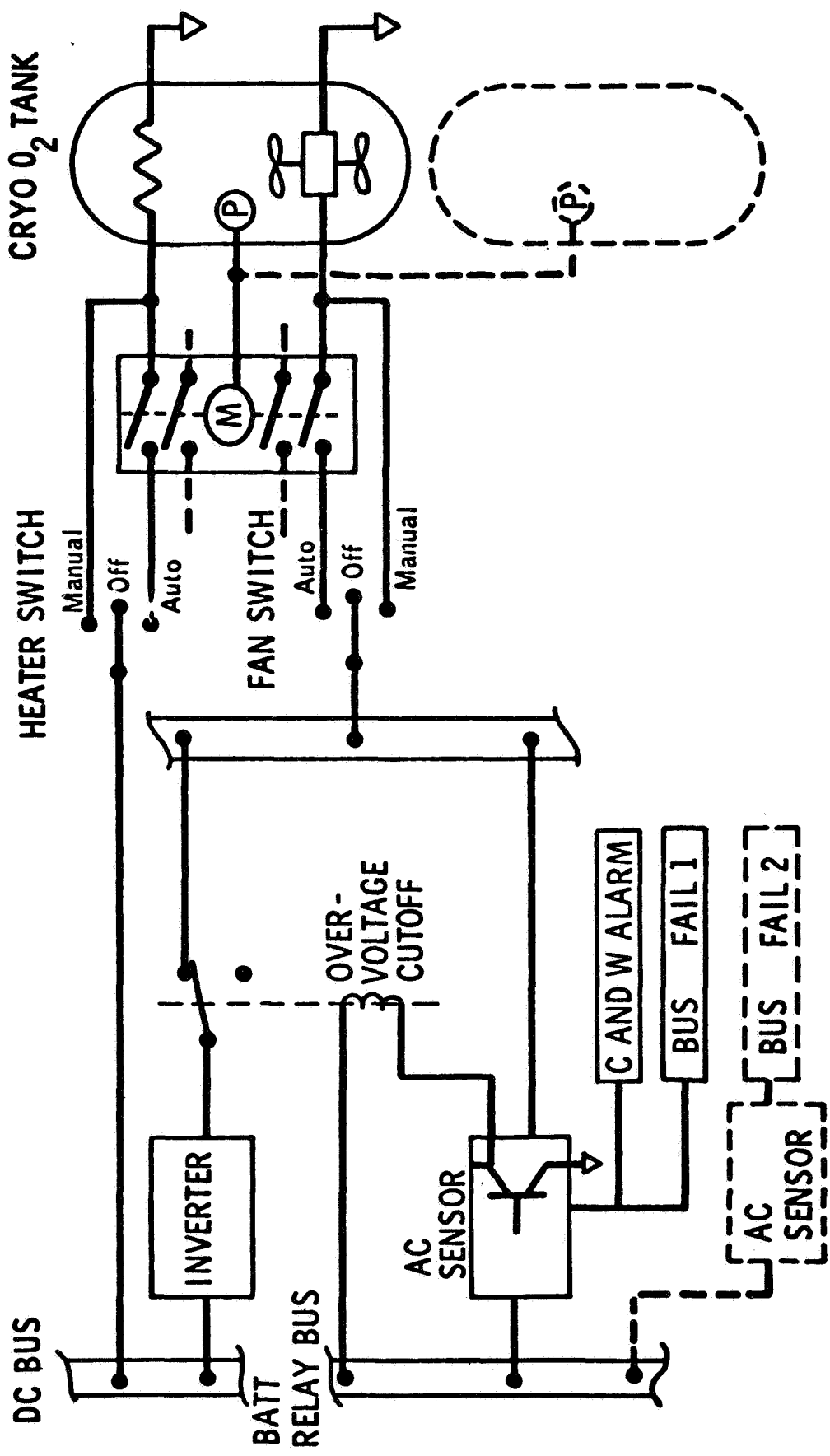
I would point out that several critical systems operate off AC -- for example, the stabilization and control system -- and you do have to be able to stabilize and control to carry out the maneuvers that are involved in an earth orbital mission or in any of the more ambitious missions.

The drive for the gimbal motors on the spacecraft engine is powered by AC, so you have got to have AC to control the spacecraft and to carry out several of the rotating machinery driven functions like pumps and so on.

Will you put on the next chart?

Our people were able during the flight to correlate bus dropouts in the AC system with switching functions of turning off the heat in the cryogenic tanks. This is symbology that shows the cryogenic oxygen tank that is carried in the service module. There are two tanks, and there is redundancy. You have to supply heat in these tanks in order to maintain the pressure which expels the oxygen for use by the fuel cells and for driving it up into the command module for life support. The heat is supplied by redundant means, in the one case by an electric heater which is powered off of the DC bus, and the redundant system is a fan which also can furnish heat. It is put in there to avoid stratification of the cryogenics, but it also puts in heat. Now, that fan is

# AC CIRCUIT FOR CRYO TANKS



driven off the AC bus.

In the automatic system, which is the normal mode of operation and the mode that Apollo 7 took off in, a pressure sensor in the cryogenic tank signals a motor switch if the pressure drops below a certain level. That motor switch then closes and brings -- when you are in the automatic position within the cockpit -- brings DC power off the DC bus to the heater, brings AC power off the inverter bus to power the fan. This is the redundancy features.

Now, when the pressure is built up to prescribed level, the motor switch is signaled to turn off and drops the load both from the DC bus and from the inverter.

Now, one of the features of the AC system is an AC voltage sensor that is pictured here which powers a trip relay which in the case of an overvoltage coming out of the inverter trips the inverter off the bus so you have an AC failure. And this then is fed to the caution and warning panel so the crew is aware immediately of the AC bus failure.

And in the three events in Apollo 7 the crew reset the breaker and AC power picked up.

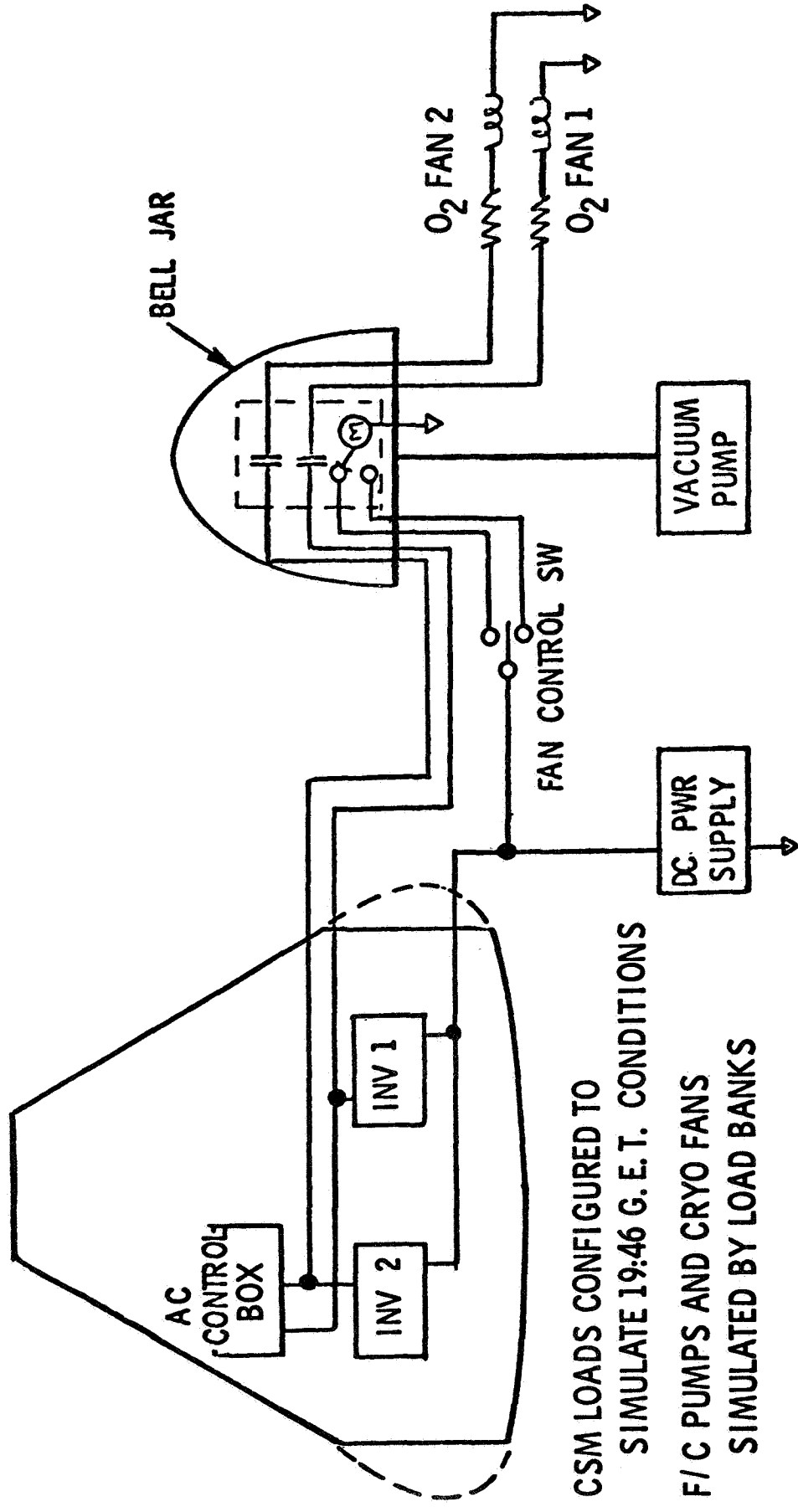
Now, this correlation was made during Apollo 7, and the suspicion at that time was that as the AC load was dropped off the bus, the overvoltage trip sensor sensitivity was such that the voltage rise that occurs when you drop load off the bus was enough to trip this and drop the inverter off the bus.

So for the balance of the Apollo 7 mission we set up such that one of the systems was left in automatic, the other was set up in manual, so that we didn't have a dropping of both loads at the same time. And after setting up that way, this did not recur in the Apollo 7 mission.

Now, after the mission we got back to the command module, of course, which included the inverter and the sensing circuits, did not include the motor switch or the cryogenic tanks which are in the service module and therefore didn't come back to us.

The next chart shows a post-flight test setup where we took the 101 spacecraft at Downey, set it up with its

# AC BUS DROPOUT POSTFLIGHT TEST CONFIGURATION



CSM LOADS CONFIGURED TO  
SIMULATE 19:46 G.E.T. CONDITIONS  
F/C PUMPS AND CRYO FANS  
SIMULATED BY LOAD BANKS

inverters and its electrical system in a normal mode, put a direct current power supply on of impedance characteristics to match the fuel cell supply, and put this motor switch, a motor switch, into a vacuum bell jar, because it is in vacuum in the flight environment, and set up a stimulation of the fan and the heater.

We were able in this test setup then to find that this motor switch which is protected against moisture intrusion but is not vacuum protected, has the motor open the contacts, if the conditions of outgassing were exactly right in the vacuum environment, would cause arcing at the switch contacts, a corona discharge type effect in a near vacuum, and under certain conditions the arcing would occur to the case, put an extra load on the inverter and thereby cause the dropout.

The next chart shows some of the results of this testing where, depending on the details of the number of hours that the switch had been exposed to the vacuum and therefore the outgassing of the protective materials and therefore the exact state of the vacuum in the case, in one case at one particular level the transient that occurred was very small, didn't hit the overvoltage trip. Under a slight corona discharge there was a slight overvoltage and then recovery. This is at the time the corona discharge occurs in the switch contacts in the case. It didn't drop it out.

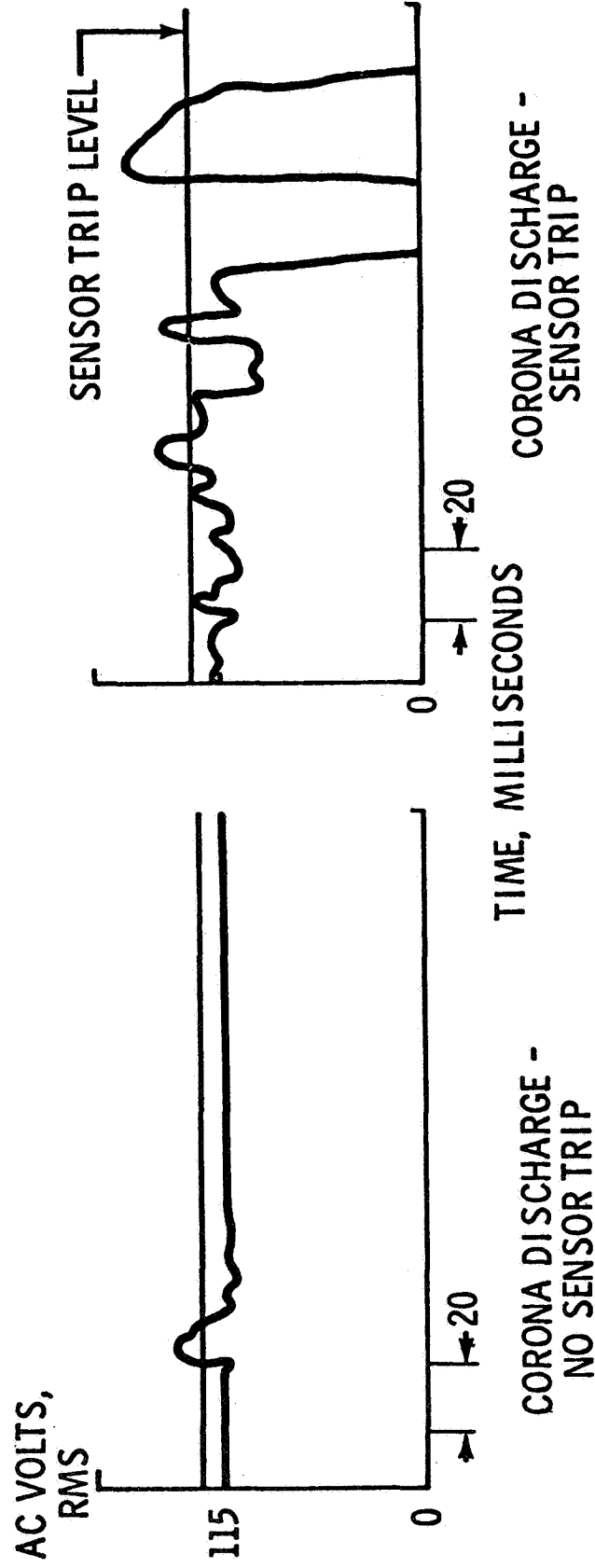
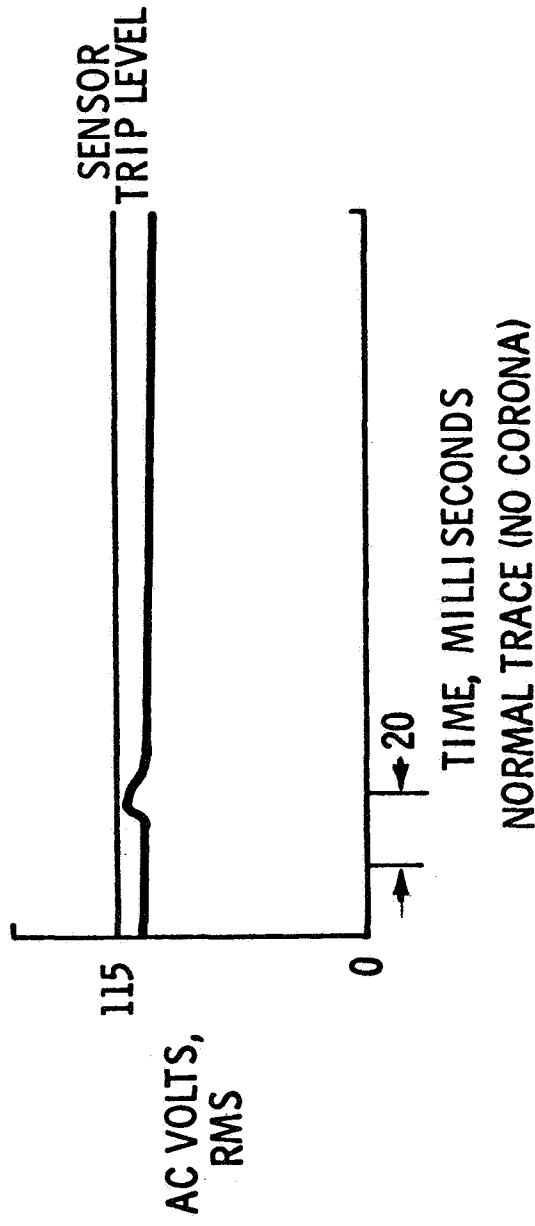
But when the vacuum conditions and the number of molecules at the switch case were just right, then a more severe corona discharge occurred and caused actually the AC voltage in the corona discharge to the switch case to put on overload on the inverter and to drop it off the line.

Now, we're fortunate in this case that we were able to precisely reproduce the conditions after we had got the bulk of the hardware back from the flight. We are also fortunate that it is no procedural difficulty to not use the automatic feature of this cryogenic tank heating system that these motor switches were put in there to drive. So we have introduced into our procedures already for the subsequent flights manual controls of the pressure of the heating and therefore the pressurization of the cryogenic tanks and have eliminated this problem as a problem.

Now, other than this, which was significant and important, on which we have been able to reach an entirely

# AC BUS DROPOUT

## OSCILLOSCOPE TRACES-AC ANOMALY (LAB TEST)





adequate technical evaluation and conclusion, the inverters and the AC system operated precisely as designed and indicated very ample margins of load-carrying capability and control characteristics.

I went over that one only to show you an example of an abnormal condition that occurred on the Apollo 7 flight which we were able to control for that flight's purpose but have been able to resolve insofar as the reliability for subsequent operations is concerned.

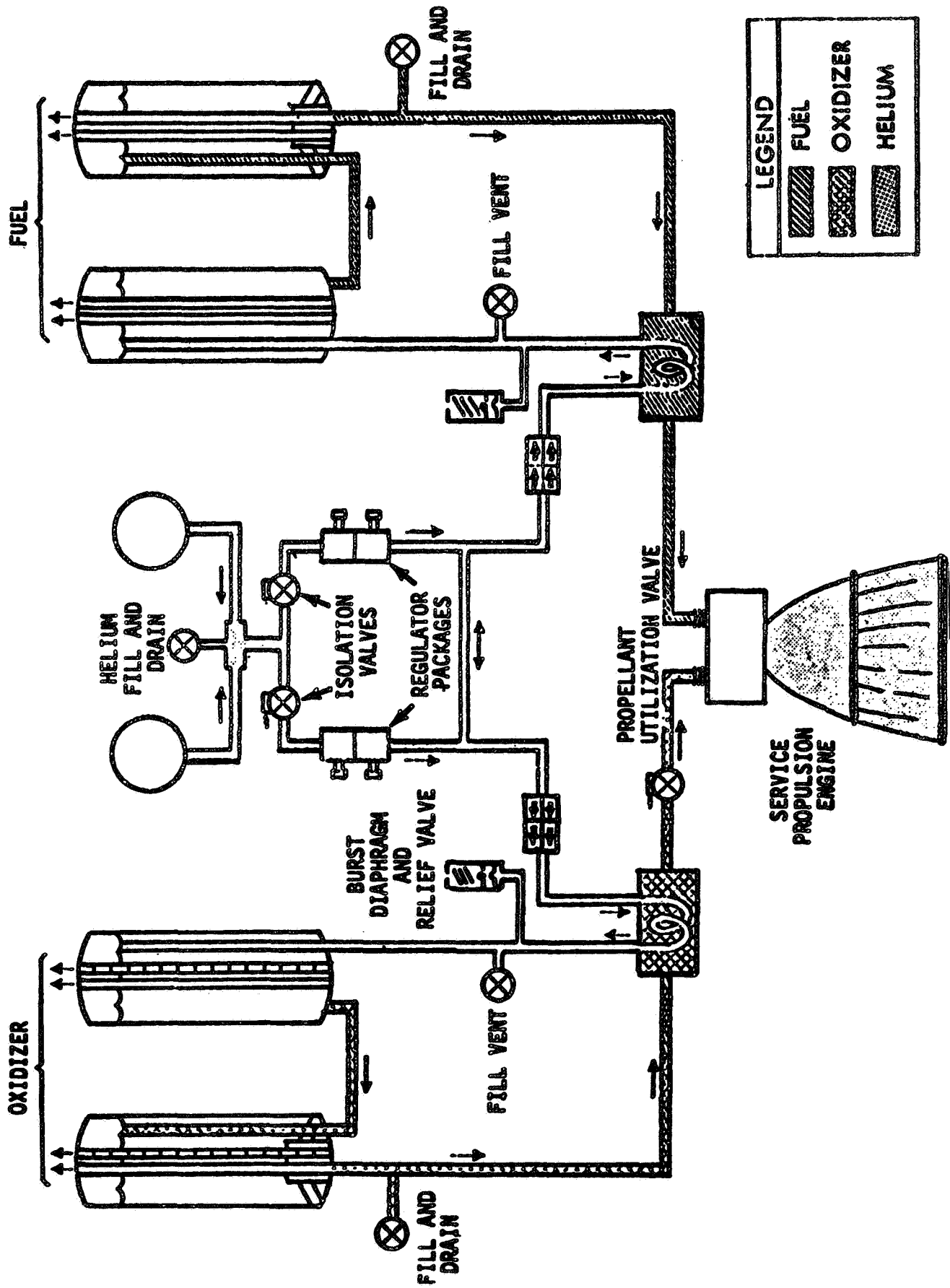
I would like to talk about another class of thing which we reviewed in great depth just as an example. I have mentioned, and it's obvious, that the spacecraft engine, the some 20,000 pound thrust service propulsion system engine on the service module, is used to provide the engine for lunar orbit insertion and then for transearth injection to get us back out of lunar orbit on the way home. If it didn't work to get us into lunar orbit, we would like a lunar pass. But once we are in lunar orbit it has got to work to get us out.

In an earth orbital mission, as you know, we have during most of Gemini, and we did in Apollo 7, maintained the capability to provide retrograde energy for deorbit using the reaction control system. Once you get out in lunar orbit, you don't have that fallback or backup capability, and you are depending on the service propulsion system.

Now, from the beginning, the importance of this system was recognized and was provided for in the design. The design is a simple design and is highly redundant. There is only one part of the engine which is really a structural part that is not redundant. That is the thrust chamber and the injector that puts the propellants into the thrust chamber and the engine nozzle. And because it's not redundant, it has wide factors of safety and strength margins which have been tested elaborately and extensively over the years in many normal and many abnormal operating conditions.

Now, the rest of the system is highly redundant. You observe here the pressurization system that pressurizes the propellant is redundant with two helium models which are each isolatable from the other -- isolation valves.

# SERVICE PROPULSION SCHEMATIC



And regulator packages and check valves are all redundant, including in the case of the check valves are quad-redundant.

This helium pressurization system pressurizes the fuel tank by entering helium into this area which pressurizes and pushes fuel out through this system and into the engine.

Now, the control valve is also redundant, quad-redundant, and is exemplified here.

This is a schematic of the pressurization system, valving and regulation. Redundant control valves which operate valve actuators. And I might point out here in our qualification testing we found one high-temperature condition in which this control valve actuator operated marginally. This was found some time ago in ground testing, and for that reason we did change out the engine and its valve system which is called integral on the 103 spacecraft, after our decision to prepare ourselves for the range of optional missions that I have described.

That is an example -- I guess the most important example -- of the change action that we took. It is the only significant one -- to cover ourselves for all options, including lunar orbit, as we evaluated our situation back in August.

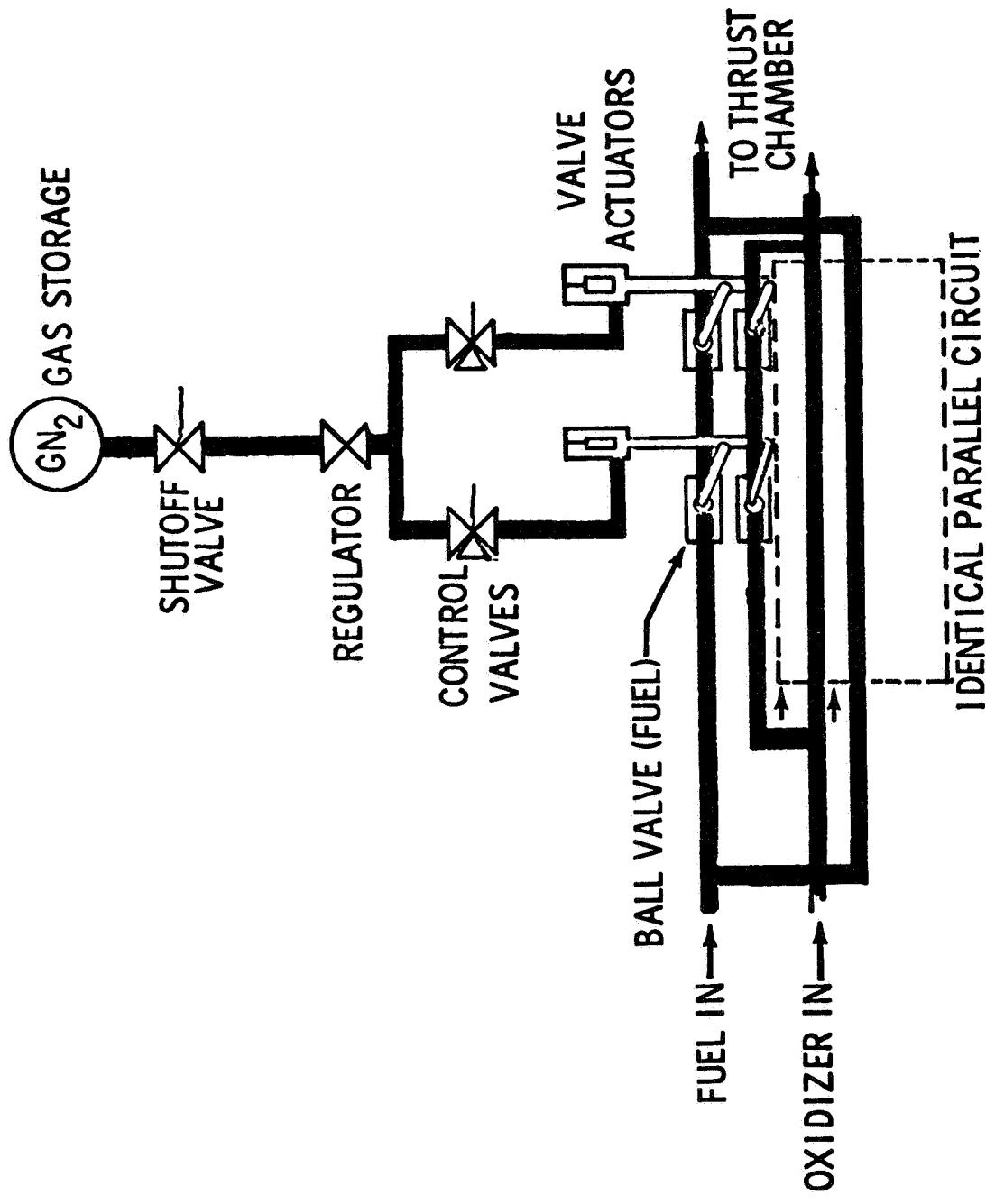
Now, the so-called ball valve which controlled the fuel and oxidizer into the injector and thrust chamber are series-redundant in each case, and then in a loop that isn't shown here another pair of series valves for each fuel and oxidizer, which therefore makes it quad-redundant.

So you can suffer valve failures of open or closed in this quad-redundant setup and still be able to either start or stop the engine.

Next chart.

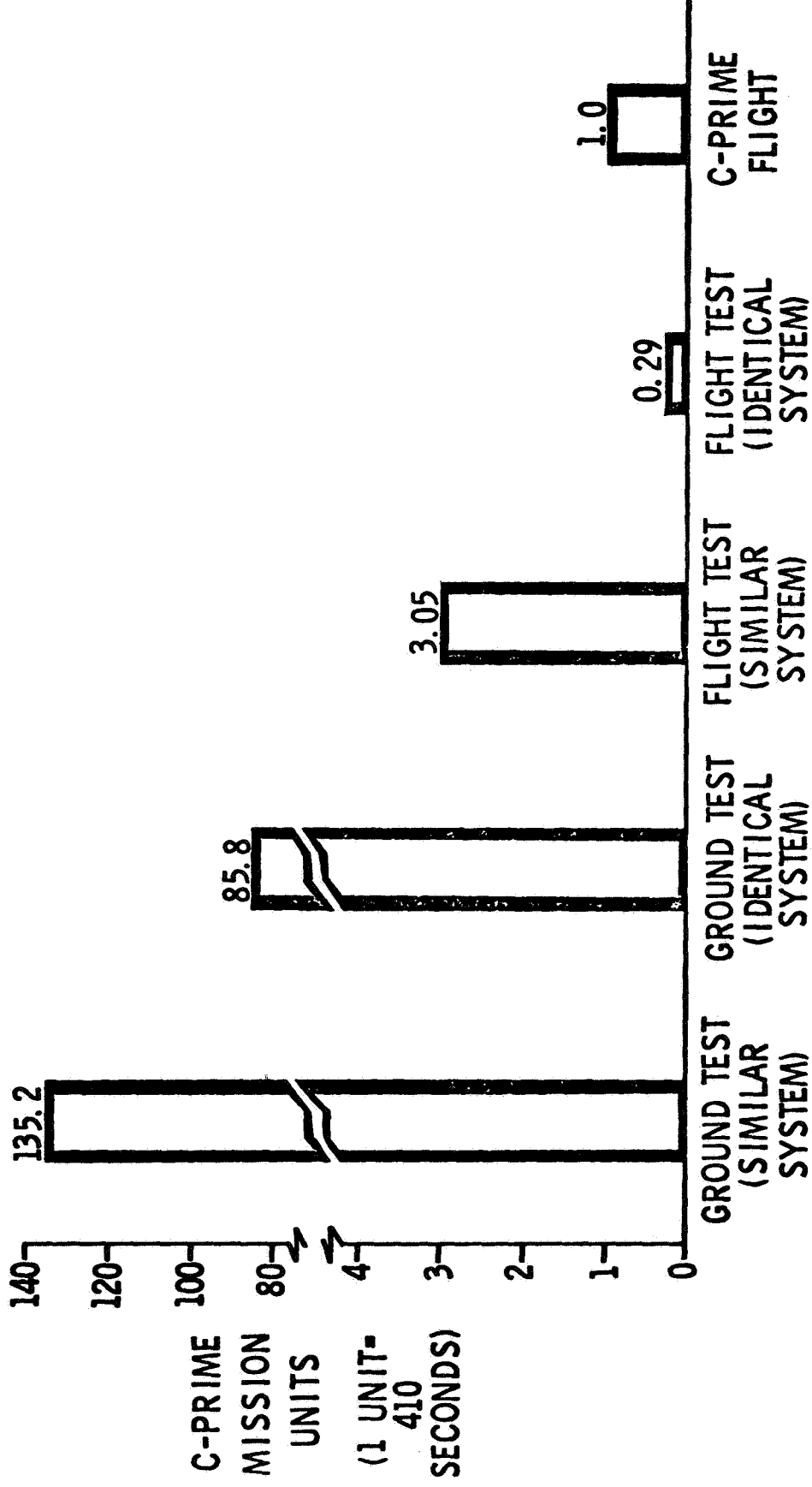
There is a lot of experience with this engine now. This summarizes engine firing time put into units of a lunar orbit C-prime mission where there are three burns that we will require for a lunar orbit mission. Those are two burns

# SERVICE PROPULSION SYSTEM THRUST CHAMBER VALVE



# SERVICE PROPULSION SYSTEM

## ENGINE FIRING TIME



to enter lunar orbit -- Bill Schneider will talk more about those -- one burn to get us out of lunar orbit, and then we have provided for one burn for midcourse correction on the way to the moon, one burn for midcourse correction on the way back.

We may not need either of those two midcourse corrections, or we may need both.

So what we have done here is to provide for one midcourse burn and say that the nominal engine burn time for this mission is 410 seconds for the maneuvers required.

That then gives us one unit, if you want to look at it that way, of engine time for a lunar orbit C-prime mission.

The Apollo 7 burn duration was about 30 per cent of that. You recall we conducted a total of eight burns on that mission, most of which were short, one of which was about a minute in duration.

I would point out that in previous flights, because we conducted an alternate mission on Apollo 6, the service propulsion system which was a Block II propulsion system, burned for some nearly seven minutes to propel us out to the high apogee after the launch vehicle didn't restart. We have then on similar systems -- these were the prior unmanned flight tests -- three units of operating time.

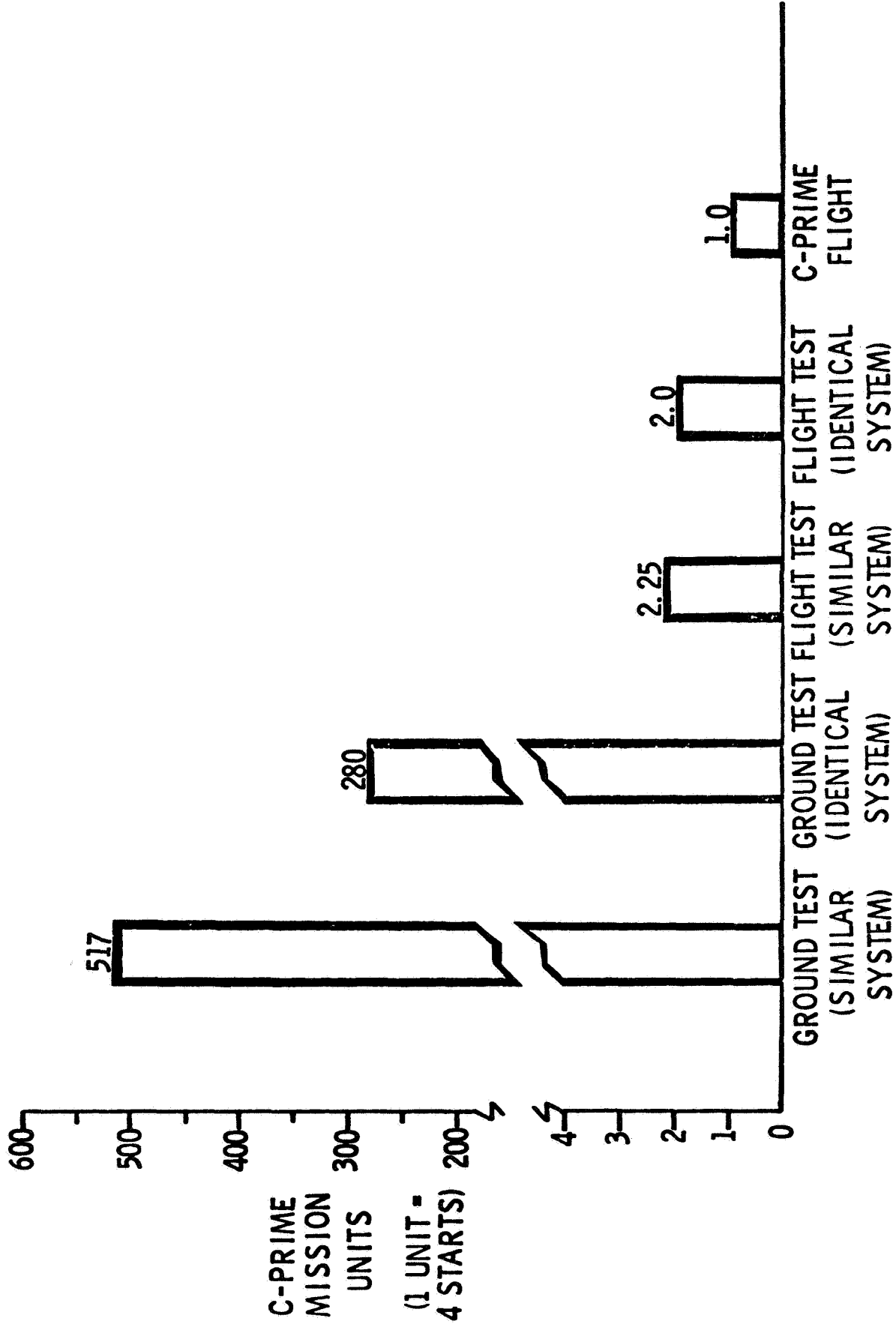
In a ground test with the identical system we are going to fly, we have 86 mission duration tests, a total operating time equivalent to 86 missions.

In the ground test of the similar systems which go back into the Block I -- and there haven't been very many significant design changes over the years -- we have a total of 135 units of mission operating time.

Now, the next chart shows you engine starts, and one of the features of hyperbolic engines is once you are satisfied with the structural features, usually if it starts it will run. For the C-prime mission based on four starts as a nominal mission, there is a unit of one. Apollo 7 started eight times. You recall there was not a bobble in

# SERVICE PROPULSION SYSTEM

## ENGINE STARTS



the SPS. Review of all the data from Apollo 7 indicates absolutely flawless performance, not an anomaly anywhere.

In the unmanned test preceding Apollo 7, we had the equivalent of two and a quarter times mission duration.

In identical systems tested on the ground, we have 280 starts. And similar systems which incorporate the applicable parts of Block I experience, 517.

One of the messages here is -- what I said in the beginning -- that our design concepts lean heavily on designing with the necessary redundancy and integrated mode features, then thorough testing on the ground, and minimum flight demonstration. This exemplifies that.

Next chart now.

One of the things about a rocket engine that one has to be sure of is combustion stability. We have in these spacecraft engines -- and I say "these" because it applies also to all of the launch vehicles as well as the lunar module engines -- demonstrated stable engine.

In recent months we have conducted 157 bomb tests with this engine. This is the means by which testers introduce pressure spikes into an engine while it is running to see whether or not the engine goes unstable or the pressure spike that is introduced damps itself out, and if it damps itself out in a few milliseconds, which is the specification, then you have got a stable engine, because you try to make it unstable and it recovers.

We have done it under a variety of test conditions using the flight ablative chamber as well as the steel chamber -- and the steel chamber has been proven to be a more severe test condition -- using over-nominal mixture ratios, temperatures and pressures, and it is a stable engine.

For this reason we don't have to have a flight combustion stability monitor nor a rough combustion cutoff system in this system.

Next chart.



# **SERVICE PROPULSION SYSTEM INJECTOR STABILITY EVALUATION**

- **157 BOMB TESTS**
  - **ABLATIVE AND STEEL CHAMBERS**
  - **HIGH AND LOW MIXTURE RATIO**
  - **HIGH AND LOW PROPELLANT TEMPERATURE**
  - **HIGH AND LOW CHAMBER PRESSURE**
- **NO INSTABILITY**

Now, that last series that I went through on the engine was to say Apollo 7 validated in detail down to the fine-grain data that the engine and system, propulsion system, works as designed, and I have gone through the brief discussion here to demonstrate some of the essential features of the design itself and of the very deep and thorough test program that has preceded this point in time.

Now, in all of our missions the ground control facilities focused in the Mission Control Center at Houston are essential to the flight control and to the navigation. Navigation in a lunar mission is an obvious essential. And we have to be satisfied before we venture out of earth orbit that our capability to plan, monitor and direct the navigation functions and do the necessary computations in our facilities based on the tracking data from the worldwide network is indeed adequate to ensure the accuracy of navigation that is necessary -- to be sure we don't hit the moon, for example.

What I have summarized here is one of the things Chris Kraft summarized for all of us yesterday, including Dr. Paine -- major functional capabilities in the Mission Control Center computer program.

This is a complex of 360-75 computers that is an adjunct to the Mission Control Center at Manned Space Flight Center, Houston. That program has in it a complete earth orbit rendezvous capability which we will be using not too long after the first of the year when we fly 504 with spacecraft 104 and LM 3 for the D mission to get the LM in the manned flight.

This complex can simulate and monitor the S-IVB translunar injection maneuver. It can plan, target, simulate and monitor the midcourse maneuvers that are required for all of the functions involved in a lunar mission, including return to the nominal mission, deviation during any part of the flight. It computes the delta-V necessary to return to the nominal flight path, maintains continuous computation to provide for a free return to earth.

This is the feature, one of the features, of the lunar trajectory. It can provide for lunar flyby and maintain the nominal height of the perilune as it passes the moon. The lunar orbit insertion maneuvers which are computed

## **MISSION CONTROL CENTER COMPUTER PROGRAM**

### **MAJOR FUNCTIONAL CAPABILITIES**

- **COMPLETE EARTH ORBIT RENDEZVOUS CAPABILITY (SAME AS D PROGRAM)**
- **SIMULATE AND MONITOR S-IVB TRANSLUNAR INJECTION MANEUVER**
- **PLAN, TARGET, SIMULATE, AND MONITOR:**
  - MIDCOURSE CORRECTION MANEUVERS AND MANEUVER PLANNING INCLUDING:**

**RETURN TO NOMINAL MISSION**

**FREE RETURN, FIXED LUNAR ORBIT ORIENTATION**

**FREE RETURN, LUNAR FLYBY, NOMINAL PERICYNTHION HEIGHT**

**FREE RETURN, LUNAR FLYBY, SPECIFIED PERICYNTHION HEIGHT**

**LUNAR ORBIT INSERTION MANEUVERS**

**LUNAR ORBIT ADJUSTMENT MANEUVERS**

## **MISSION CONTROL CENTER COMPUTER PROGRAM**

### **MAJOR FUNCTIONAL CAPABILITIES (CONTINUED)**

- **PLAN, TARGET, SIMULATE, AND MONITOR:**

#### **TRANSEARTH INJECTION MANEUVERS**

#### **TRANSEARTH CORRECTION AND REENTRY MANEUVERS**

#### **RETURN TO EARTH ABORT MANEUVERS (ALL MISSION PHASES)**

- **PROVIDE LANDMARK ACQUISITION DATA**
- **PROVIDE INFORMATION FOR POINTING OPTICS TO EARTH, MOON, AND STARS**
- **PROVIDE PLATFORM ALIGNMENT DATA**
- **ORBIT DETERMINATION FOR ALL PHASES OF MISSION (WITH 2- AND 3-WAY USB DOPPLER DATA)**
- **PROVIDE AEROMEDICAL DATA PROCESSING (AS PLANNED FOR D MISSION)**

**STATUS: FORMAL TESTING COMPLETE DECEMBER 9, 1968**

**PROGRAMS HAVE SUPPORTED ALL CONTROL CENTER ACTIVITIES EXCELLENTLY  
SINCE OCTOBER 15, 1968**

in the ground-based computation facility transmitted up to the spacecraft to be executed. And the lunar orbit adjust maneuvers.

The next part shows some additional features. It can plan, target, simulate and monitor the transearth injection maneuvers, the transearth correction and reentry maneuvers.

As you know, to reenter the earth from a lunar mission one has to hit a fairly narrow corridor fairly accurately. Bill will have more to say about that. At any point in the mission it can provide the solution for return to earth under any required abort conditions.

It provides landmark acquisition data to tell the spacecraft where to point to pick up a landmark or a star for its own on-board platform alignments. It can provide information for pointing the optics of the spacecraft guidance and navigation system to the earth, the moon or the stars. And it can provide platform alignment data so that if necessary it can pass up to the crew the settings for aligning its platform for inertial space orientation, such that the crew doesn't have to go through the lengthy checklist that sets up the platform. All they have to do is get the ground-based data and go through the final line.

It can determine the orbit for all phases of the mission using a variety of data, including the two- and three-way doppler data that comes back from the Manned Space Flight network.

Now, this program that I have gone through has been in development really for years. It has been refined now for use on the C-prime lunar orbit mission. Formal testing will be complete on the 9th of December.

They have by this time completed simulations using the computer complex and the spacecraft and crew of all of the maneuvers that are involved in the lunar orbit mission.

The next chart.

Now, this is the summary of the major functional capabilities of the on-board computer program. This is the digital program that is stored in the on-board guidance and navigation computer. We call it the Colossus Program. In

## **ON-BOARD COMPUTER PROGRAM**

### **MAJOR FUNCTIONAL CAPABILITIES**

- LAUNCH MONITORING
- TRANSLUNAR INJECTION MANEUVER MONITORING

- EXECUTE AND MONITOR:  
MIDCOURSE CORRECTION MANEUVERS

#### **LUNAR ORBIT INSERTION MANEUVERS**

- PLAN, TARGET AND MONITOR

#### **TRANSEARTH INJECTION MANEUVERS**

- CREW CHARTS AND BLOCK DATA
- REENTRY GUIDANCE
- PLATFORM ALIGNMENT WITH STAR SIGHTINGS

- NAVIGATION

#### **STAR/HORIZON SIGHTINGS**

#### **LUNAR LANDMARK TRACKING**

**STATUS: FLIGHT ROPES DELIVERED OCTOBER 14, 1968**

**SIT PERFORMED OCTOBER 29, 1968**

**SFRR AND CARR CONCLUDED SATISFACTORILY NOVEMBER 8, 1968**

that program are the features that allow the crew on their on-board displays to monitor the launch, to monitor the transearth injection maneuver, and to be able to compute and execute if required -- this is the independent capability of the spacecraft from the earth if fallback on board is necessary -- to execute and monitor midcourse corrections, to maintain the path to the moon or back, to compute and execute on board the lunar orbit insertion maneuver, plan, target, and monitor for the transearth injection.

So there is on-board capability independent of the ground to compute getting into lunar orbit or coming back out of lunar orbit.

In addition, crews have charts and block data like they have carried on all the manned flights, with which independent of computers they can get a rough solution.

The on-board computer can also provide for reentry guidance and for platform alignment using star sighting and for navigation using star or horizon sightings and lunar landmark tracking.

Now, the flight ropes -- this is the piece of mechanism that all of this digital program is put into -- were delivered to the Cape on the 14th of October. The software integration test between the space vehicle and ground control facilities was performed on the 29th of October. The software flight readiness review and the customer acceptance readiness review were concluded satisfactorily on the 8th of November. So the on-board program has been developed over a long period of time and fully checked out and demonstrated.

Next chart.

Now, let me just summarize here before we give a further description of the mission itself what we have concluded are the gains to be made toward our objective of a manned lunar landing from a lunar orbit mission.

As I said before, there are many things we can't do in earth orbit. We have got to get out into space and get into the lunar environment to do many of the things that are required in connection with the landing itself. One of these is navigation, going out, in orbit, and coming back. And

# **PROGRAM GAINS FROM A LUNAR ORBIT MISSION**

- **NAVIGATION (TRANSLUNAR, LUNAR ORBIT, TRANSEARTH)**
  - **LIGHTING CONSTRAINTS**
  - **ONBOARD BACKUP CAPABILITY**
  - **TRACKING/TARGETING ACCURACY**
- **COMMUNICATIONS AT LUNAR DISTANCES**
  - **SPACECRAFT/GROUND COMPATIBILITY**
  - **HIGH GAIN/OMNI ANTENNA PERFORMANCE**
- **THERMAL ENVIRONMENT**
  - **THERMAL CONTROL MODES**
  - **SPACECRAFT THERMAL RESPONSE**
- **OPERATIONAL EXPERIENCE DIRECTLY APPLICABLE TO LUNAR LANDING MISSION**
  - **VERIFICATION OF MISSION PLANNING, COMPUTER PROGRAMS, CREW PROCEDURES, CREW TIMELINES, ETC.**



involved there are the lighting constraints which are an important element of determining our launch window.

In other words, we need the lighting on the lunar surface where we intend to land at a fairly low sun angle to evaluate our on-board computation ability of the guidance and navigation system and our ability to track accurately the targets on either horizon or stars or on lunar surface. These are all functions required in the navigation process.

Now, communications at lunar distance. It's to ensure the compatibility between the spacecraft and the ground. These are a matter of signal gain, distances, pointing accuracies, and so on.

And the performance of our high-gain and of our non-directional antenna system on the spacecraft.

We have determined, incidentally, and discussed thoroughly, what we would do if the high-gain antenna didn't function properly, and we have had some development difficulty getting the high-gain antenna up to a sufficient state of demonstrated performance.

We can, in fact, accomplish this mission with complete safety without the high-gain antenna in the case it does not work according to its design requirements.

In the thermal environment, you will recall in Apollo 7 we did some maneuvers to evaluate the so-called passive thermal control, the rolling or tumbling of the spacecraft. And this we can evaluate, insofar as deep space operations or local lunar effects, only by operating in that environment.

There is much operational experience that is directly applicable to the lunar landing mission that we obtain and therefore obtain a significant step toward the more complex operations where, carrying the lunar module and with more functions to accomplish, we'll have less time and less propellant and performance margins and so on to be able to attain this element of experience.

And we can very importantly verify that our mission planning, that our computer programs, that our crew procedures

both on the ground and in flight and our crew time lines provide adequately for more complex operations ahead.

Next chart.

Now, as I have said, there are added risks as we get away from proximity to the earth. The minimum return time is considerably longer than it is for an earth orbital mission. We will be of the order of three days away from land as compared with the prior manned flight where we have been of the order of half an hour to three hours away from return to earth.

This then places need for increased reliance on the principally two major subsystems, life support, which supports pressurization and oxygen for human survival, and electrical power which provides for the operation of the many systems aboard. And the service propulsion system which must work to come out of lunar orbit.

Next chart.

We have done a careful assessment of the risks that are involved in this mission -- in other words, the delta risk. I have said many times, and I remind us all again, that on each manned flight there are risks. You won't for some number of years be able to climb aboard a large rocket, the best in the world, without having some risk involved. I guess, for that matter, you can't really get aboard your car and go very far anymore without taking some risk. But there is risk in each one of our flights.

So we have therefore concentrated on assessing the elements of increased risk to make this next step toward our design mission.

I point out here that our spacecraft was designed for this mission. We provided redundancy to recognize the failings of both people and equipment, and we have had very good experience in our ground and flight test programs. Our spacecraft when it flies has performed exceedingly well. Our ground test experience in testing all of these subsystems has demonstrated the proper margin of design condition.

# APOLLO 8 LUNAR ORBIT MISSION

## ADDED RISKS

- MINIMUM RETURN TIME CONSIDERABLY LONGER THAN FOR EARTH ORBIT FLIGHT
- SERVICE PROPULSION SYSTEM MANDATORY FOR RETURN

## **HOW SEVERE ARE THESE RISKS?**

- **SPACECRAFT DESIGNED FOR THIS MISSION**
  - **REDUNDANT SYSTEMS**
  - **GOOD EXPERIENCE IN GROUND AND FLIGHT TESTS**
- **LARGE MARGIN FOR UNKNOWN OR ERRORS**
  - **CONSUMABLES**
  - **SYSTEMS DESIGN**
- **FLIGHT INVOLVES ONLY ONE COMPLEX SPACECRAFT**
  - **NO LUNAR MODULE**
- **ADDED RISKS, OVER AND ABOVE THOSE FOR ANY MANNED FLIGHT, ARE EQUAL TO THOSE GENERALLY INHERENT IN A PROGRESSIVE FLIGHT TEST PROGRAM**
- **PROBABILITY OF SUCCESS ON LUNAR LANDING MISSION ENHANCED**

Now, we have got a large margin for unknowns or errors on this particular C-prime mission. As Bill Schneider will show you, we have considerable margins of consumables aboard, and our systems have design margins which we will in no way tax on this mission. Because we don't have a LM aboard, we have a very considerable service propulsion system propellant margin which can be used in the event that we have the over-nominal condition that would require extra propellant for example.

We think it is fortuitous for us that we are able to carry out this flight and take one significant bite out of the whole series of things we have to do to get up to a full lunar landing capability, but a bite that doesn't involve swallowing at all. And that bite involves one complex spacecraft -- namely, command and service module with which we have considerable experience now -- but without the lunar module. We think that the added risks that are over and above those that we undertake for any manned flight are equal to those generally inherent in the progressive flight test program as you go from one step to the other, as we did in Gemini, as we are in Apollo.

And we know that the probability of success for a lunar landing is enhanced by getting this element of crew and operational experience and this element of added demonstration and data gathering as regards the navigation and performance of our whole system.

Next chart.

Finally, we have done several things in designing the C-prime lunar orbit mission to make it the safest possible mission to meet the objectives that we have established. We will launch in daylight. We will maintain all the way to lunar orbit insertion a free-return trajectory. Now, what this means is that from the moment of translunar injection onward until we reach the point of inserting the spacecraft into lunar orbit that if no further maneuvers are performed with the main spacecraft engine we can maintain the course which will fly past the moon and come back to the earth with small midcourse corrections which are within the capability of the small thrusters, the control system, free-return trajectory. And that emphasizes that.

# MISSION DESIGN CONCEPTS

- ① DAYLIGHT LAUNCH
- ② BASIC FREE-RETURN TRAJECTORY
- ③ TRANSLUNAR MIDCOURSE RETAINS RCS  
CAPABILITY FOR ACCEPTABLE EARTH  
LANDING
- ④ TWO BURN LOI
- ⑤ MINIMIZE LUNAR ORBIT TIME
- ⑥ MINIMIZE RETURN TIME
- ⑦ TRANSEARTH MIDCOURSE FOR ENTRY  
CORRIDOR
- ⑧ SHORT RANGE NON-SKIP ENTRY TRAJECTORY

Translunar midcourse correction can be accomplished with the small thrusters and will keep us on a course that brings us back to an acceptable earth landing.

This mission is designed with a two-burn entry into lunar orbit. The first burn puts us on a 60 x 170-mile orbit around the moon, and the second burn then circularizes at 60 miles. Those are nautical miles.

We have minimized the time in lunar orbit, ten revolutions, approximately 20 hours. We have minimized the return time. Our nominal mission discussed over the years has contemplated about 72 hours, about three days, return to earth from the moon. We have sufficient propellant margins on this flight because we don't have a LM aboard and sufficient reserve demonstrated in the heat shield to come back a little bit faster, so we have built this trajectory to 58 hours return time. That minimizes the time back to earth from the moon.

There is a midcourse correction provided in the trans-earth leg to maintain entry into the reentry corridor. And we have provided for a short-range, non-skip reentry which provides us about three levels of backup for being able to make that reentry return. Bill Schneider will describe that.

Now, we can put the lights on now. What I have tried to do is to remind you of and summarize for you the background of the last year that has led us up to a state of readiness for a flight to lunar orbit and return with Apollo 8 and describe for you some of the more significant technical factors that we have examined, many of them in great depth, in the last several months or the last few weeks and several days in particular.

With that I would like to turn it over to Bill Schneider who will describe for you the Apollo 8 lunar orbit mission. Bill Schneider is the mission director for this mission.

Bill.

SCHNEIDER: Good morning, ladies and gentlemen. I would like to take the next few minutes to describe for you what we're going to be doing on Apollo 8 mission. I will be stepping through a little bit fast because it is a

long mission. Of course, as far as we are concerned, the mission has just about begun.

If I may have the first slide, please, just to bring you up to date and to point out to you what our activities are going to be in the upcoming days, I prepared this slide here to show what the coming events are. We will start off on this Friday, the 15th -- a slight error in the slide here -- with our flight readiness test. This is our last big electrical test of the spacecraft and launch vehicle to assure that it is ready for flight.

This is a crew participating test, and the crew sits in the capsule in their shirtsleeves.

We then have a reasonably leisurely pace on through our normal checkout procedure until we come to our countdown demonstration test. The countdown demonstration test is going to be run in the same sequence that we ran the Apollo 7. That is, we will first have a wet countdown demonstration test -- that is, a complete simulation from beginning to end of the countdown without the crew. We will use all the propellants on board and all of the procedures will be just as if the crew were there. However, the capsule will be unmanned.

We will then recycle, and the next day we will dry CDDT, at which time the crew will be in the final test. We will go through the final day without the propellants on board.

This is a reasonably leisurely schedule. We have ample time in here to accomplish all of these.














We do reserve the right for ourselves to shuffle dates around a little bit here and there, although I don't anticipate that there will be anything major come up between now and then.

However, on the 7th, if we finish on that date, we then have a recycle time -- may I have the next slide, please -- for our countdown.

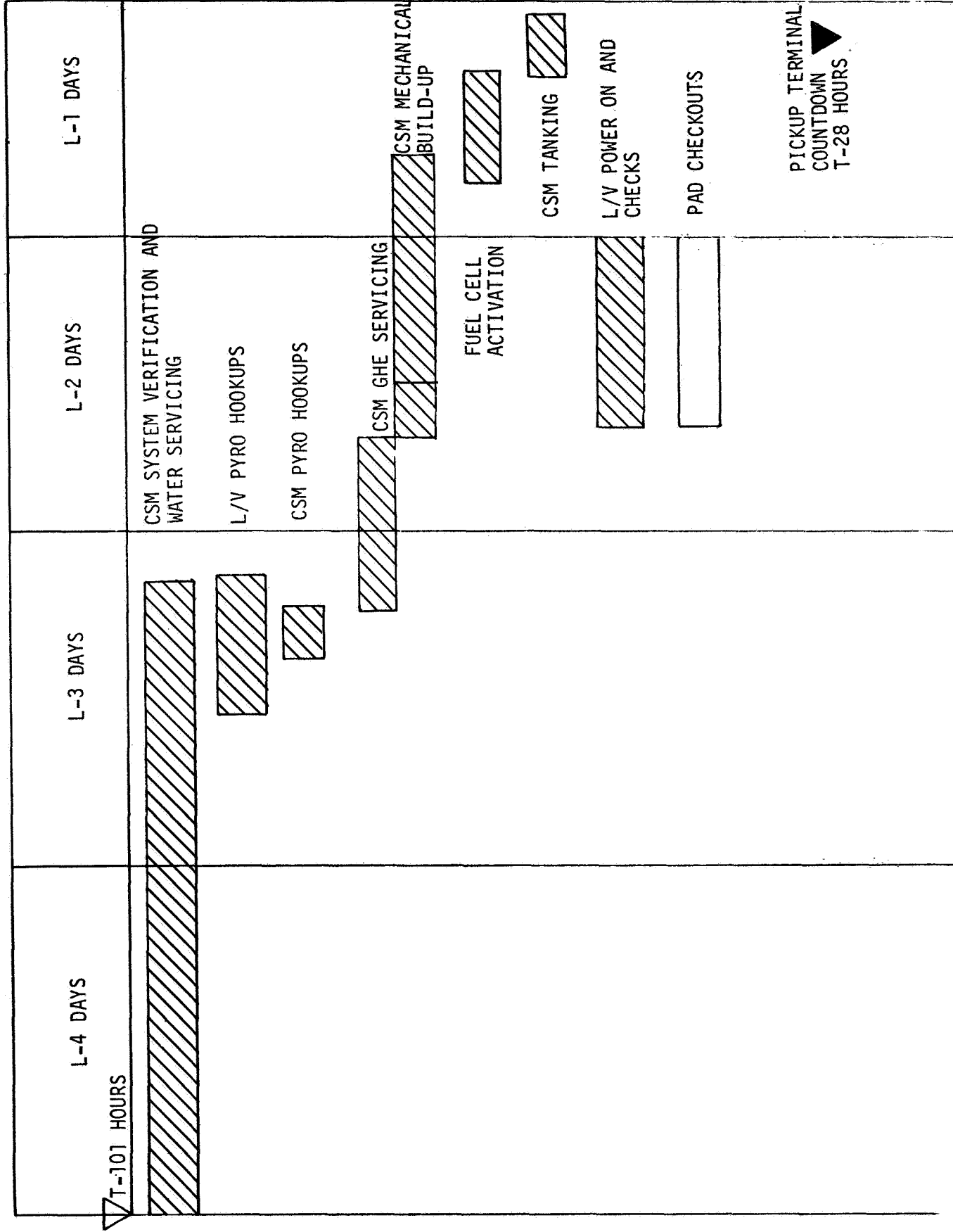
Now, we have a long countdown, which begins on the 16th of December. You will notice we have about nine days in case we come up with any problems in the countdown



# MAJOR EVENTS TEST SCHEDULE FOR APOLLO 8

EVENT	NOVEMBER	DECEMBER
S/C FRT	13 	
SV FRT	14  	
RCS LEAK AND FUNCTIONAL TESTS	17 	
SPS LEAK AND FUNCTIONAL TESTS	20  22 	
SV HYPERGOLIC LOADING	23  27 	
RPI LOADING		29 
COUNTDOWN DEMONSTRATION TESTS:		2  6  7  

# APOLLO 8 LAUNCH PREFLIGHT / COUNTDOWN



demonstration test before we pick up our count. And it is a long Apollo count, 101-hour count, which will be picked up about 9:45 p.m. on the 16th of December, and we will go through all of the checks that we normally go through leading up to our final count.

May I have the next slide, please.

This begins about 10:45 on the night of the 19th. This isn't an empty space in here, believe me. It just so happens that these are the only bars that have been picked out.

We do enter our normal built-in hold, a six-hour hold, at 4:45 p.m. on the 20th, picking up again the count at minus nine hours at about 10:45 p.m. that evening, aiming for a launch on the 21st at about 0745.

We have not completely determined the precise moment of liftoff as yet. It will be about 7:45 in the morning, give or take a few minutes.

May I have the next slide, please.

Looking at our criteria for launch windows, first we have established these general criteria. Primarily, we desire a daylight launch on consecutive days. That is, we would like very much to be able to view this launch. We have set up our window such that we always have a free-return trajectory, and we desire that we have G-type lighting in the Apollo zones.

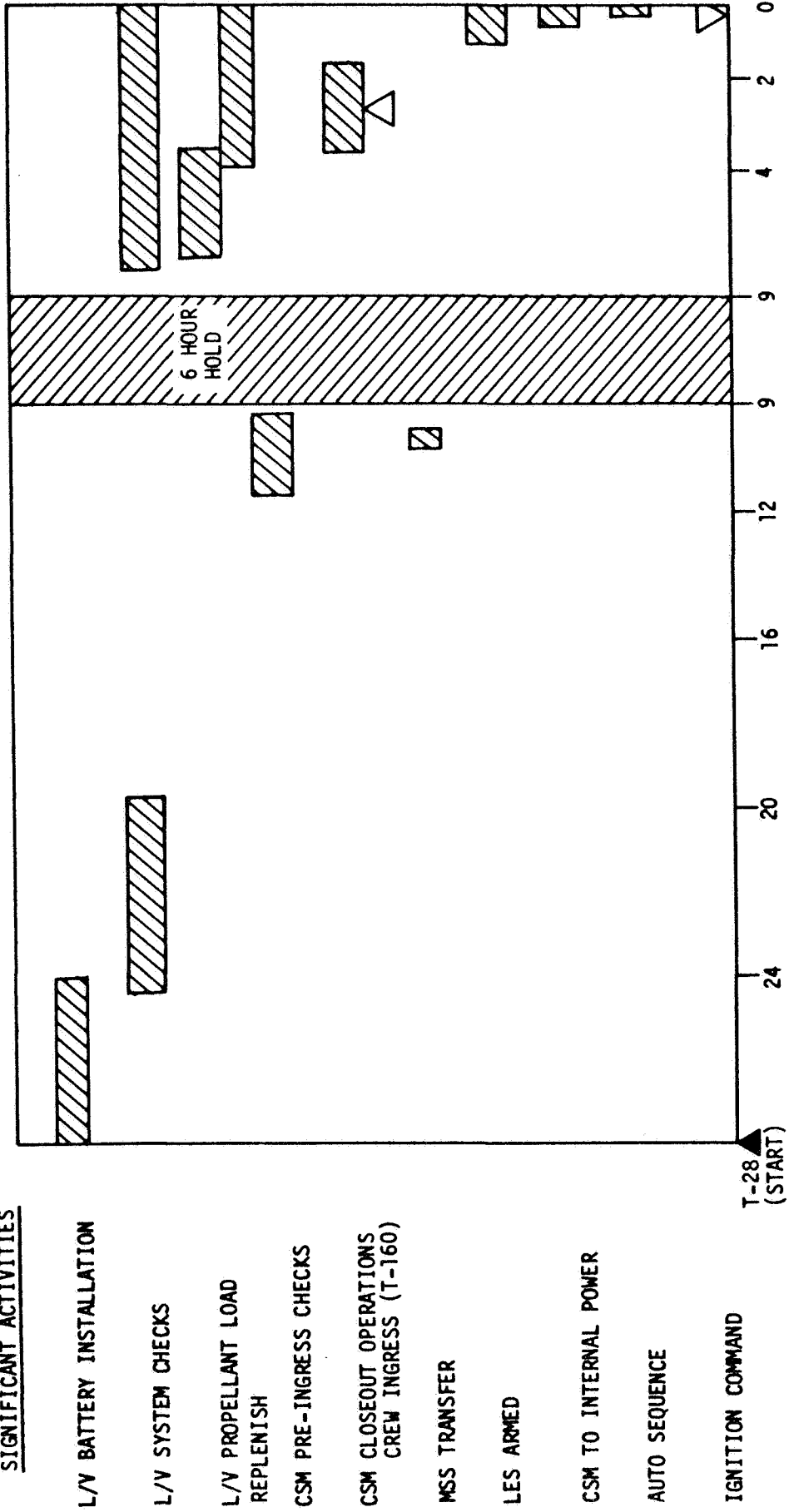
We are constrained to launch azimuth -- that is, directions from the north -- in which we can launch by range safety and by performance from 72 to 108 degrees. And we will in all probability utilize this full range.

And we have set up our launch windows such that we have two opportunities for any launch time for a trans-lunar injection, the first opportunity being at the second rev and the second opportunity being one rev later.

Looking at the primary windows that we are aiming for, we are picking up, as I stated, the launch window on the 21st at about 7:45, and we do have approximately a

# APOLLO 8 TERMINAL COUNTDOWN

## SIGNIFICANT ACTIVITIES

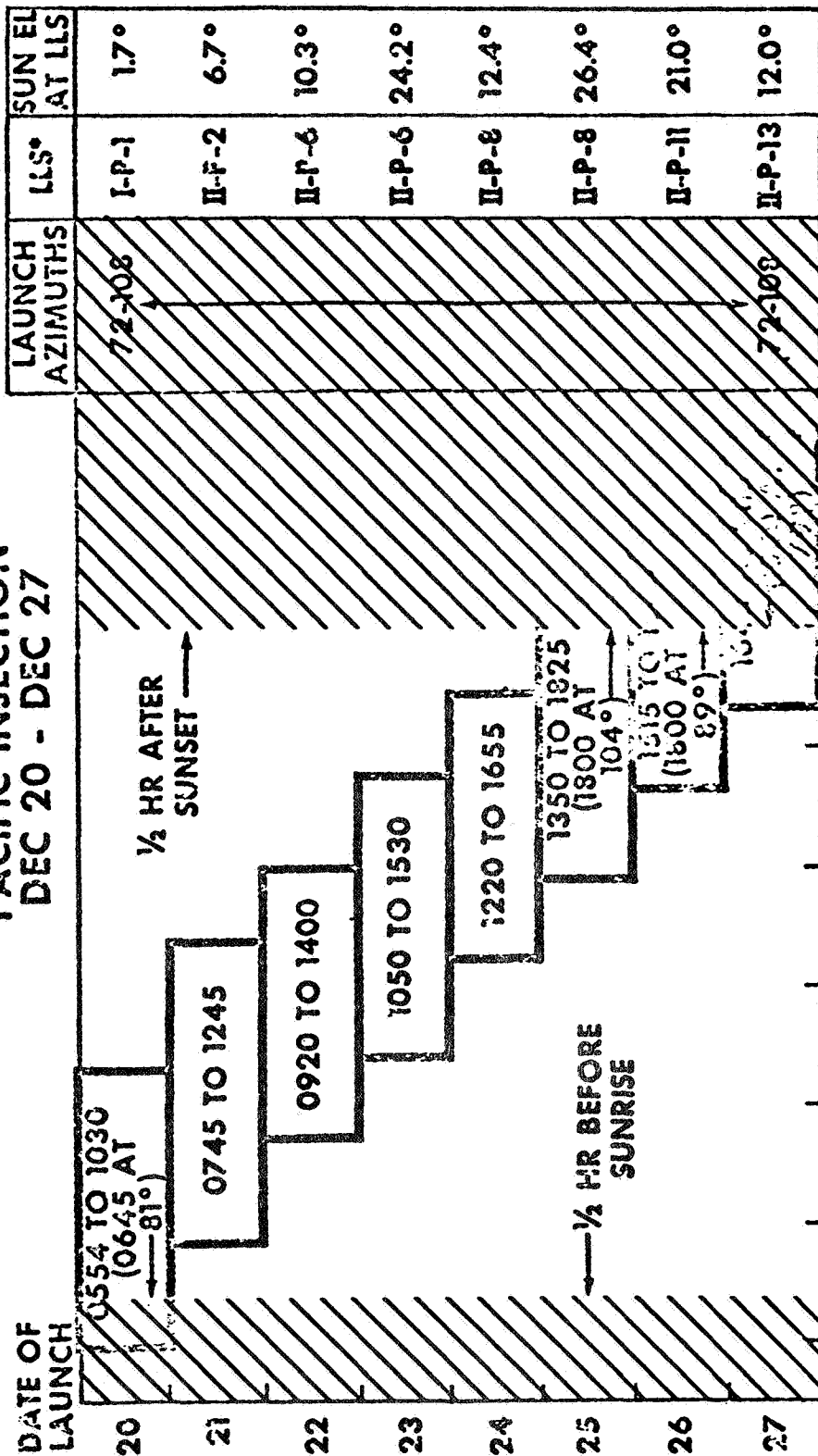


## **LAUNCH WINDOW GUIDELINES**

- **DAYLIGHT LAUNCH ON CONSECUTIVE DAYS**
- **FREE-RETURN**
- **APPROXIMATE "G" TYPE LIGHTING IN APOLLO ZONE**
- **72° - 108° LAUNCH AZIMUTH RANGE**
- **TWO INJECTION OPPORTUNITIES:**
  - **1ST ON 2ND REV**
  - **2ND ON 3RD REV**

# LAUNCH WINDOW SUMMARY

PACIFIC INJECTION  
DEC 20 - DEC 27



6 8 10 12 14 16 18 20 22

LAUNCH TIME - EASTERN STANDARD

•LLS - LUNAR  
LANDING SITE

five-hour launch window. These are all Eastern Standard Times, I might add. We have about a five-hour launch window that we will be aiming for that day.

On successive days the launch window moves down through the time period as you can see here, with on the 26th here picking up at it looks like about four o'clock.

We do desire, as I said, a daylight launch, both picking up the count and ending the count. If we do go on the 21st, we will be going for the Apollo zone, the easternmost Apollo zone. We will have a sun elevation angle at the seventh lunar revolution of about 6.7 degrees, which is just about what we desire.

May I have the next slide, please.

Looking at the launch phase, I might state again the launch of the Saturn V comes off from the pad 39A. Nothing unusual in our launch phase. It's a typical Saturn V launch phase, and we do have our normal abort capabilities that you're all fully aware of in case of malfunctions in the launch vehicle on the way up.

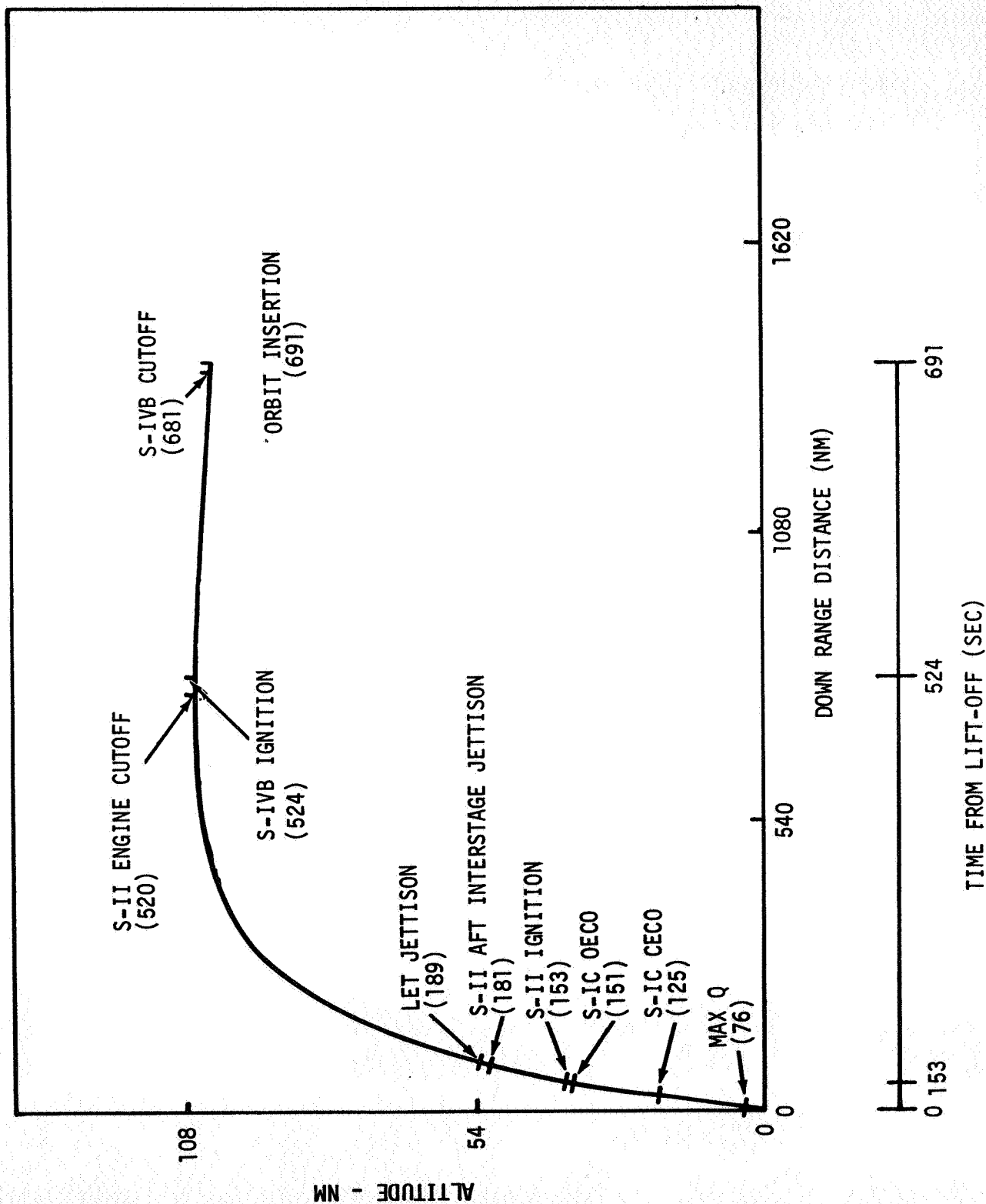
We do have alternate missions established in cases where we have early termination of thrust on one of the stages, and in general they lead to an ultimate earth orbital mission, although if we got an early cutoff of the S-IVB just prior to insertion we would probably have enough SPS capability to go on with the mission. I'm sorry. I mean S-II stage. The S-IVB, of course, is needed for the translunar injection.

So in general if we have an early cutoff and must use the SPS engine in going into a lunar orbit insertion, our first alternate mission then is a repeat of the C mission, approximately ten days in earth orbit.

Next slide, please.

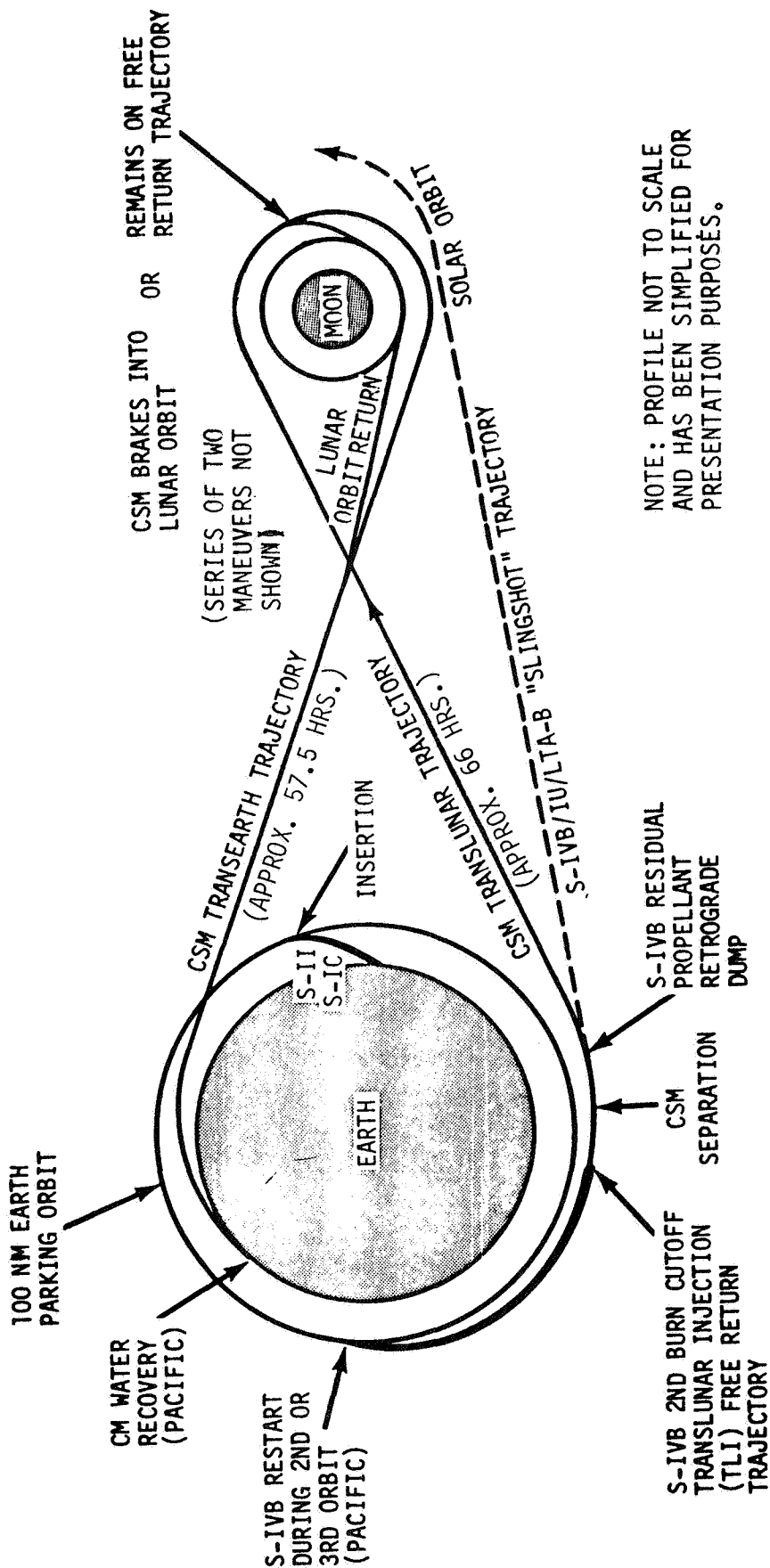
Just briefly summarizing what the mission looks like, just to orient you before I go through the phases, this is an artist's representation of what the mission looks like. It begins, of course, at the Cape with insertion, and then we go into our one orbit for systems checkout, and finally our second orbit for our lunar orbit insertion --

# APOLLO 8 NOMINAL LAUNCH PROFILE (72° LAUNCH AZIMUTH)





# APOLLO 8 MISSION PROFILE



I'm sorry -- for our translunar insertion. We do our TLI burn -- that is, the second ignition of the S-IVB -- at this point (indicating) and go on out on our coast, midcourse corrections -- I'll go into all of these in a little more detail -- and then finally our lunar orbit insertion on the back side of the moon.

As Sam said, a two-phase lunar orbit insertion, the first being putting us in a 60 x 170, and then finally a circularization at 60. Ten orbits then in lunar orbit. Followed then by a transearth insertion, come back, and then finally splash down in the Pacific.

At each one of these points we do have specific go/no go points and specific go/no go decisions, and within which we have preplanned alternates that I will be describing that we will utilize if necessary at these various points.

May I have the next slide, please.

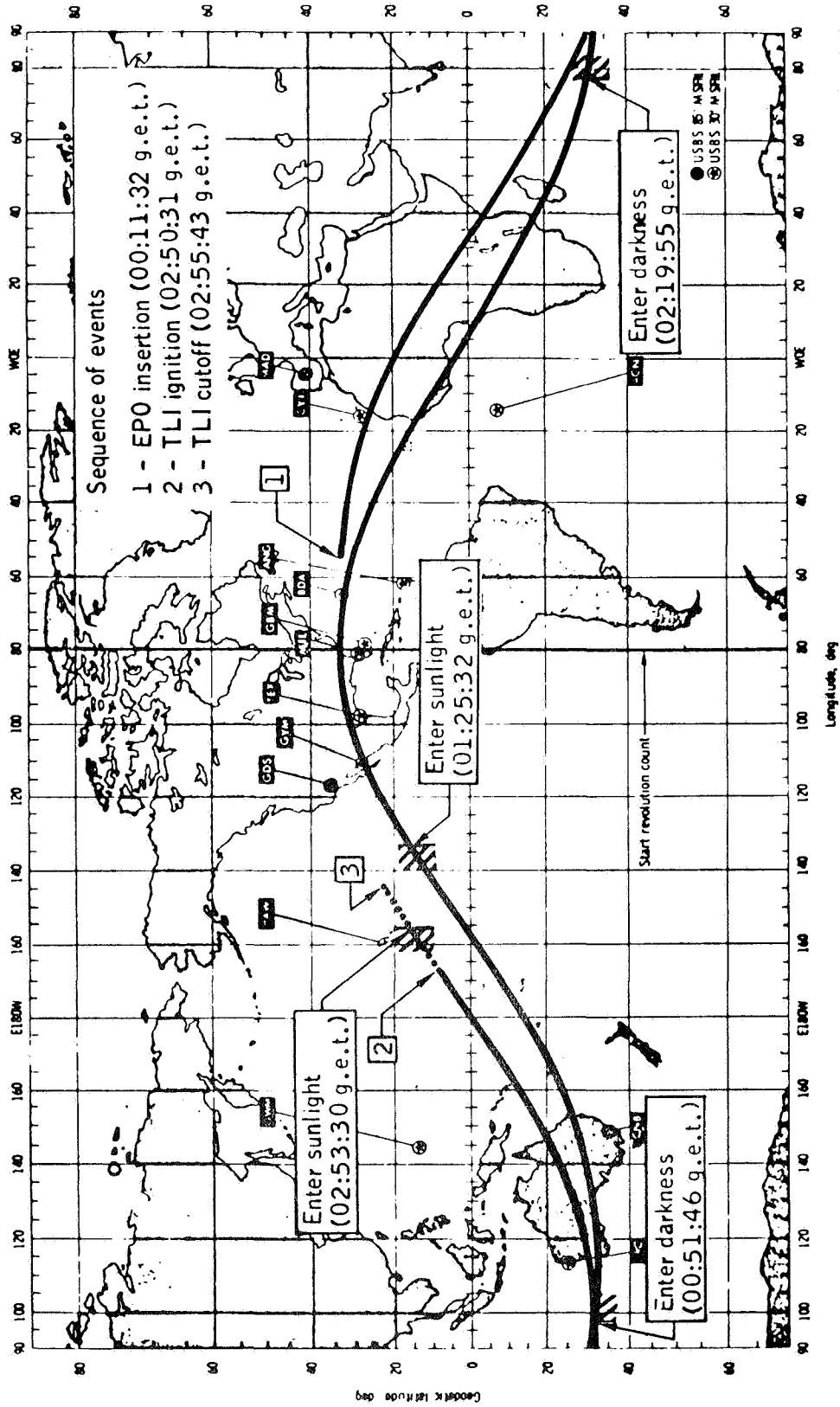
Turning to the first phase, which is, of course, the liftoff, systems checkout, and finally terminating in the second S-IVB burn, that puts us in our coast phase on out to the moon.

We have an earth trajectory that looks like this (indicating). Now, our go/no go point is set up over Australia for the large burn, and we will give the "go" providing we have assurance that the S-IVB will satisfactorily complete its second burn -- that is, providing we know of no failure in the S-IVB, providing that the consumables in the S-IVB are sufficient to not only start the burn but also to finish the burn, and that we have no known reason that the S-IVB would shut down.

Also on the spacecraft side, the "go" decision will be given only if the spacecraft is completely operable with all redundancies.

If we have an early cutoff of the S-IVB at this point in time, we have some preplanned alternate missions that basically take advantage of what are on the impulse we have imparted to the spacecraft. If we are on an orbit that will lead to a 4,000-mile apogee before we get premature cutoff of the S-IVB, we will continue on out and do a high earth

# EARTH PARKING ORBIT MISSION GROUND TRACKS



NASA HQ MA68-7197  
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orbital mission, then deorbit -- that is, up to 4,000 miles, stay there for two revs, then deorbit and stay up ten days in earth orbit, repeating those portions of the C mission that we feel we need to.

There are a series of other alternates if we get on out.

Suffice it to say if the S-IVB cuts off prematurely and our apogee is over 60,000 miles, we will assess the situation and in all probability go on a circumlunar flight using the SPS engine to provide the additional impulse that would be necessary.

If we fail to inject at this point, we will inject one rev later over at this point here (indicating).

Next slide.

QUESTION: What point?

SCHNEIDER: One rev later.

QUESTION: Over what point did you say?

SCHNEIDER: It would be roughly right around here, Bill, one rev later (indicating).

May I have the next slide, please.

Now, when we make that translunar injection burn with the S-IVB, we are as Sam has said, on our way home. That is, we will be inserting into a free-return trajectory. We have set up our flight dynamics such that at all times with our service module RCS system we can put whatever impulse might be necessary to correct any deviations for a free return trajectory that would get us back down to the earth without any need for the SPS engine.

Theoretically, of course, we are at the end of the first burn -- end of the S-IVB burn -- theoretically we are on a free-return trajectory without any correction whatsoever.

During this translunar coast period, as we go on out to the moon, we do have the points at which we plan to

# APOLLO 8

## FREE RETURN TRAJECTORY

EVENT	GET (HR:MIN:SEC)	$\Delta T$ (SEC)	PARAMETER
S-IVB TL I MANEUVER	02:50:31	311.5	PLANE CHANGE 2.60: PERIGEE 16.3 NM
PERICYNTHION	69:09:29		60.2NM
ENTRY	136:25:18		$\gamma = -6.70$ V=36, 121.5 FPS

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assess the situation, and we would abort -- that is, we would come back either circumlunar or high apogee if we lost redundancy in some of our on-board spacecraft systems.

Specifically, if we lose redundancy in the environmental control system, the service module and propulsion system or the electrical power system, we would elect to abort the mission. Also, if we lost selected portions of the guidance and control system, communication system or the sequential system.

May I have the next slide, please.

Looking at how long it would take us to come home, this slide here shows the minimum time from abort to landing as a function of time, of elapsed time, of making the decision to abort. For example, if we decided at 40 hours out that we wished to abort the mission, we would be back in something on the order of 20 hours. Similarly, if we go on out to the moon, this point here, we'd end up doing a circumlunar mission and not a high altitude abort.

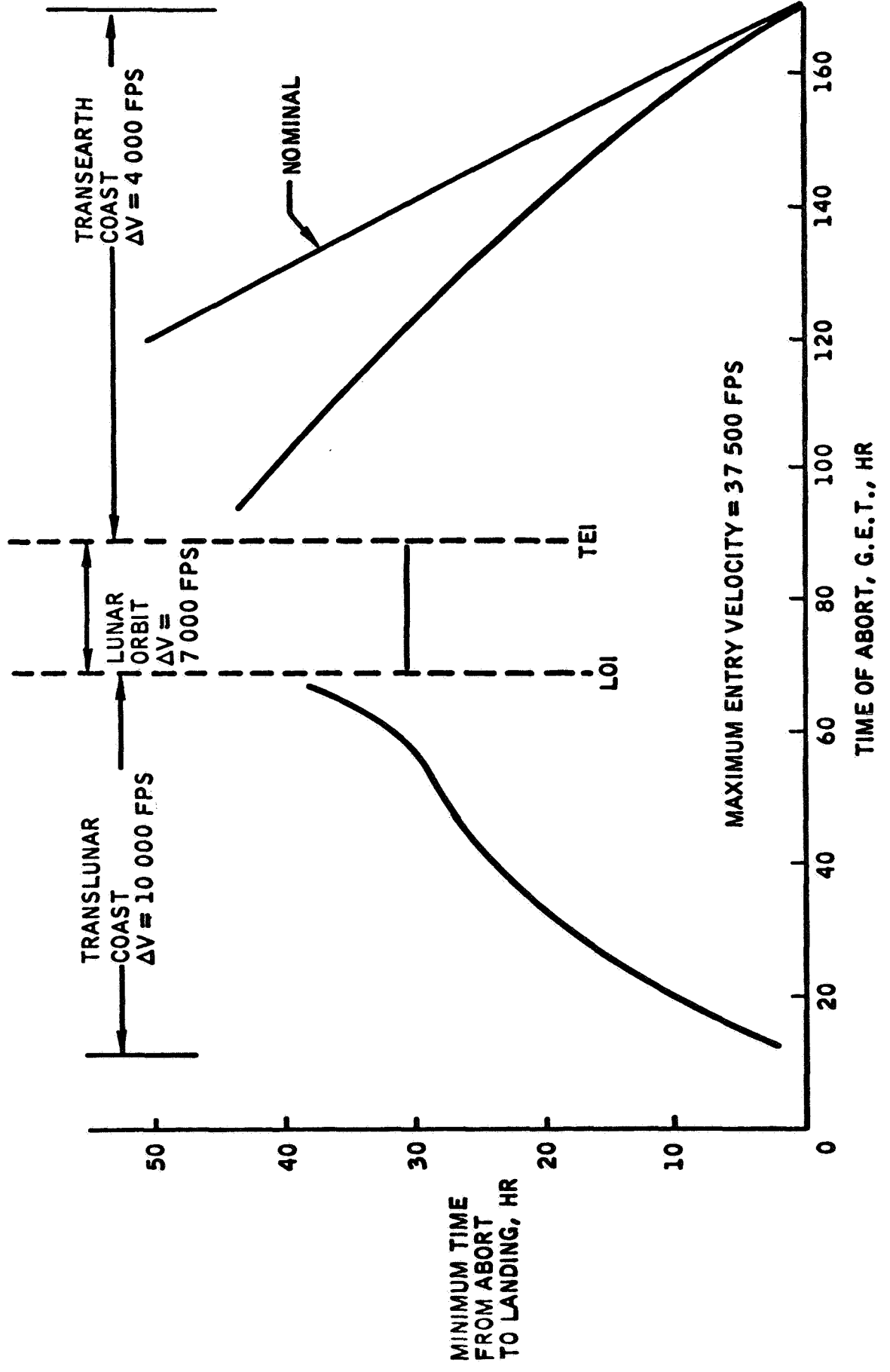
We have, although we don't have to use it to abort-- We have available for abort during that period of time 10,000 feet per second in the service propulsion system, and, as I said, if we do nothing we do abort on our normal free-return trajectory.

After the lunar orbit insertion, after the lunar orbit phase, if we elect to come home rapidly-- Nominally, as General Phillips stated, we used to talk about a 72-hour return. For this mission, roughly a 55-hour return. If we decided that we wanted to get home fast and wanted to use this 4,000 foot per second that we have available, we could have return times running along this line here (indicating).

May I have the next slide, please.

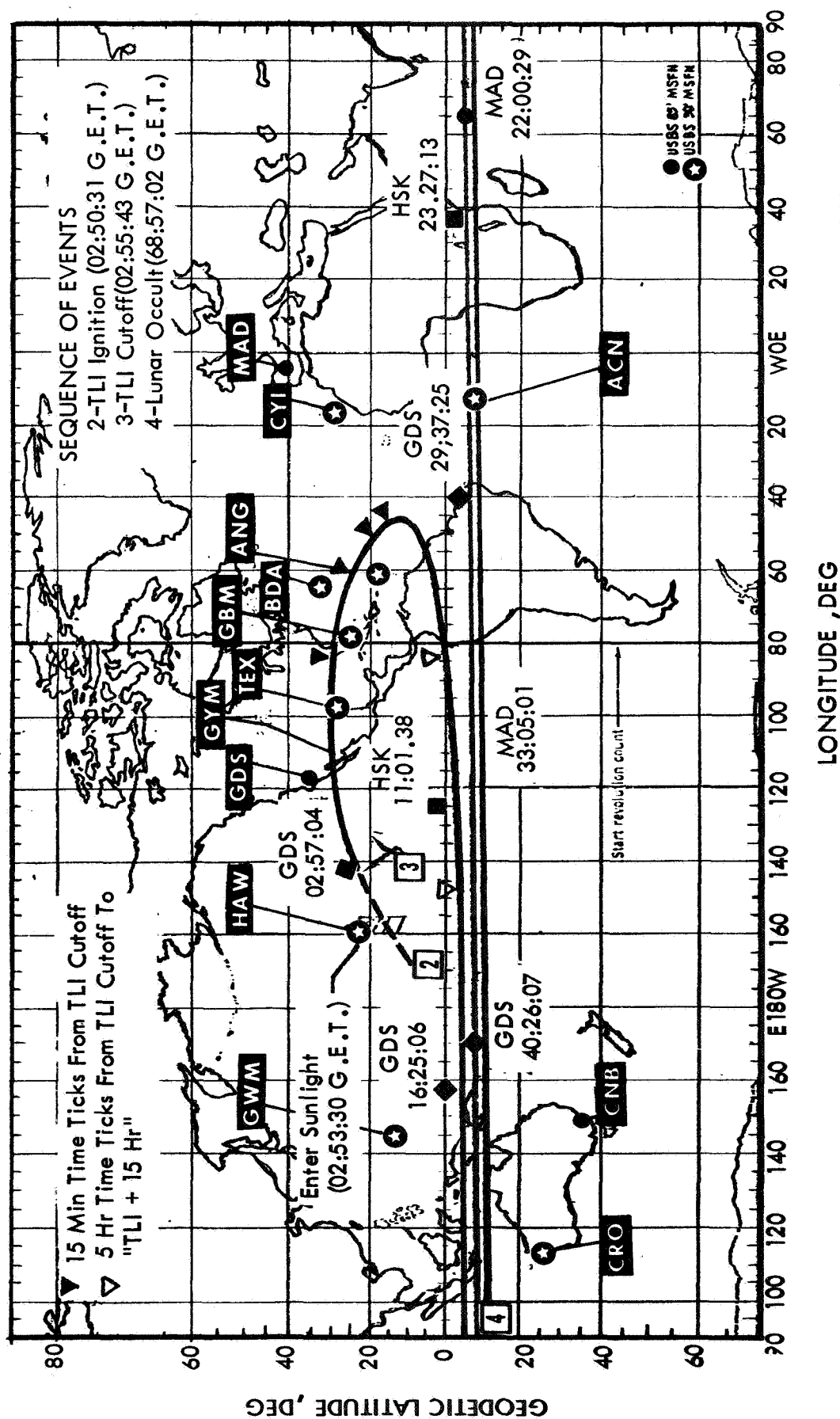
One point that I did not make is roughly in this time period here, approximately five hours into the mission, we will do a propellant dump on the S-IVB, which in essence puts us in -- that is, a retrograde dump which gives us about 90 foot per second, which basically puts the S-IVB behind the spacecraft -- and because of flight dynamics and

# TYPICAL MINIMUM RETURN TIMES DURING A LUNAR MISSION



# TRANSLUNAR COAST

DECEMBER 21, 1968-LAUNCH





orbital mechanics -- and we end up with a slingshot mode with the S-IVB on a nominal trajectory going on out into solar orbit.

At this point I would like to talk about communications and point out to you that we do have preplanned in our mission the ability to provide television back to earth. We are providing for two methods of television coverage in our flight plan, one at about 31 hours and one about 55 hours into the flight.

Now, the TV does require the use of the high-gain antenna. And, as General Phillips said, this is the first flight for the high-gain antenna, and so there is a finite possibility that we might not be able to get the TV for you. However, as General Phillips did state, the use of the omni antennas provides all of the communications that we need operationally. The loss of the high-gain antenna would cause us to lose TV in the outer fringes as well as biomedical data and high bit rate data.

We retain all telemetry data that gives us the well-being of the system. We retain all voice communications and all track, but what we do lose, as I said, if we lose the system, is TV, biomedical, and high bit rate.

We do have the decision points for midcourse corrections. These come at about six hours, 24 hours after TLI, and about 20 hours at eight hours before lunar orbit insertion. We have four decision points where we will decide whether or not we are going to make the burn.

We will make all burns that we possibly can using the service module RCS system.

If the ground computation tells us that a delta-V of less than one foot per second is required, we will make no attempt to make the burn. That is, we will not correct that. If the ground tells us that correction is more on the order of four feet per second, we will use the SPS system to make the burn.

May I have the next slide, please.

## **TRANSLUNAR MIDCOURSE CORRECTION PHILOSOPHY**

- **MAINTAIN SM/RCS FREE-RETURN CAPABILITY**
- **MAINTAIN CLEAR PERILUNE**
- **KEEP LUNAR APPROACH DISPERSIONS WITHIN  
LOI TARGETING CAPABILITY**
- **MCC TIMES COMPATIBLE WITH CREW WORK/REST  
CYCLE IF PRACTICAL**

How accurately do we know where we are going? This slide here shows our prediction on periline or 3 sigma K -- that is a high probability case -- as we go on out into the mission.

Here we have time from arriving at the moon as a function of uncertainty in where you think you are going to be. You can see that 70 hours -- that is, at the beginning of the mission -- our 3 sigma uncertainty is about 13 miles, 12 or 13 miles, and it rapidly decreases down to about five miles, and then when we get close to the moon we get down to the order of one mile.

The spacecraft, this on-board system, roughly has an uncertainty of about six miles, so we know pretty well where we are going.

Next slide, please.

The lunar orbit insertion burn, as we stated, is a two-burn and is a burn for 60 x 170 followed by 60 x 60 burn, both of which are on the back side of the moon.

Our fixed attitude burns-- And we again have specific go/no go criteria for conducting these burns. In essence, we will not conduct the burns if we have had the loss of some selected systems. And there is a complete list of those systems the loss of which would require that we not go into lunar orbit but do come back on a circumlunar flight.

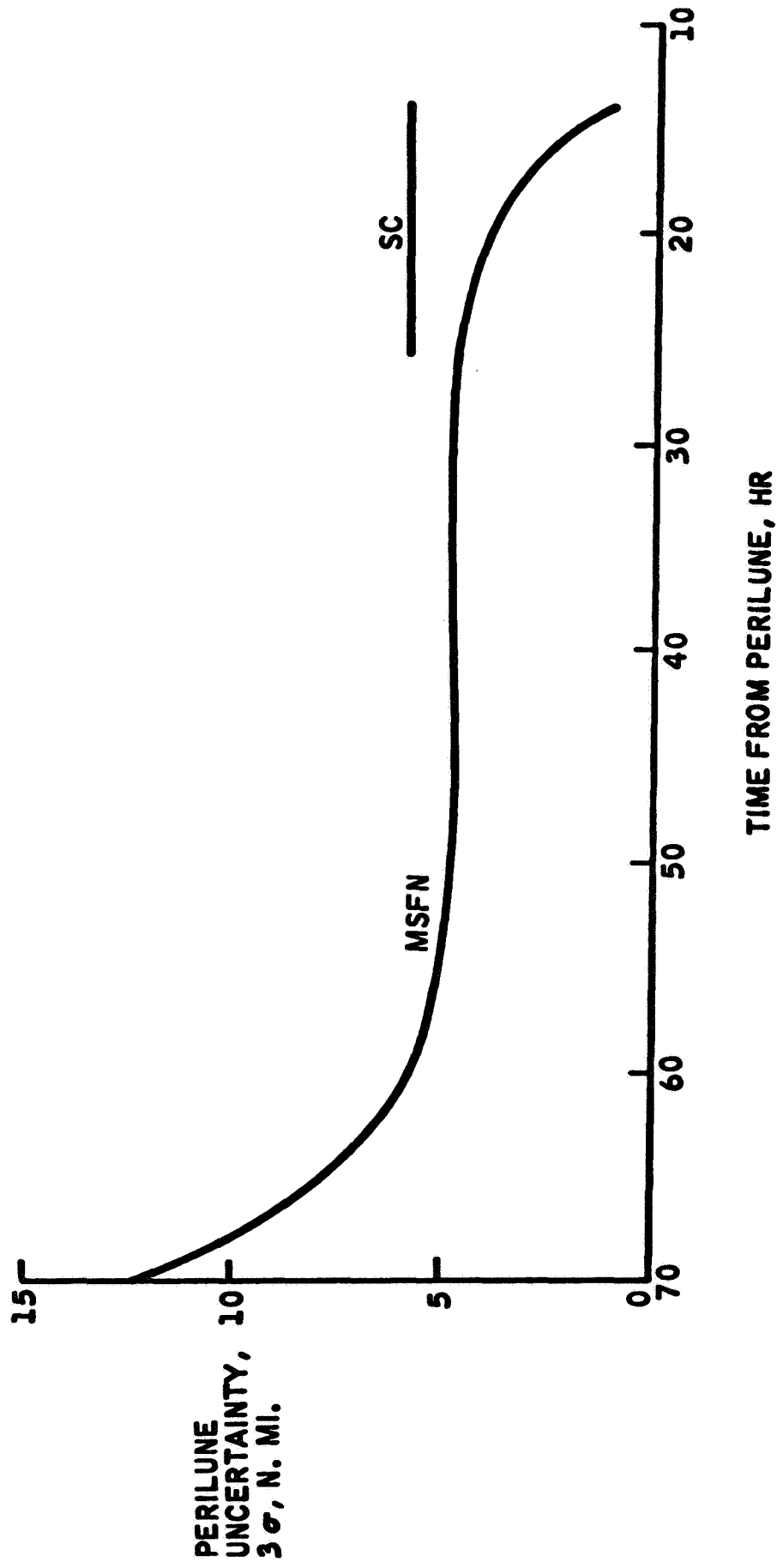
A typical example of this is if we lost one entry battery we would elect not to go in an LOI burn.

Next slide, please.

When we get into lunar orbit, this is the time line-- I'd better take a moment to explain what these are. This chart over here begins with rev 1 and goes through to rev 10 with a day/night cycle as you go on through, with the activities ticked off on bars down here.

This chart over here starts with the LOI first burn at this point here. The earth is down in this direction. The sun is up in this direction. And then the orbit time line is depicted in the spiral.

PERILUNE PREDICTION ACCURACY ( $3\sigma$ ) FOR C' ALTERNATE 1



## **LUNAR ORBIT INSERTION**

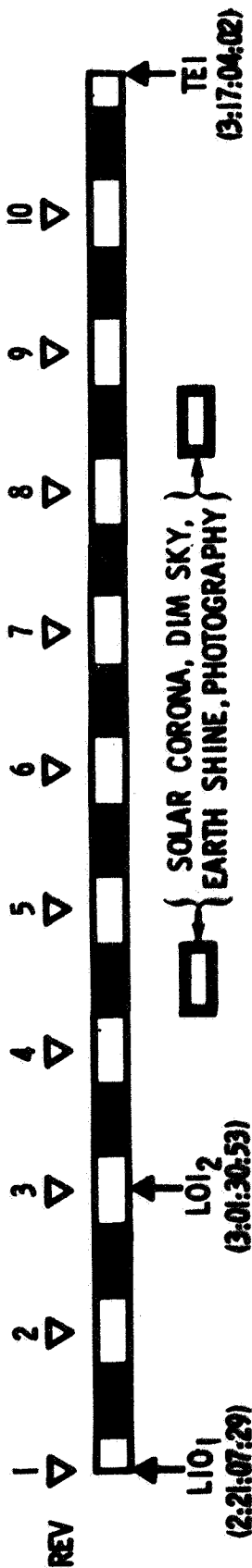
- **TWO -STAGE:**

**LOI(1) → 60 X 170 WITH PLANE CHANGE**

**LOI(2) → 60 X 60 IN PLANE**

- **FIXED ATTITUDE BURNS**

# APOLLO 8 LUNAR SEQUENCE OF EVENTS



SEQUENCE PHOTO'S

VERTICAL STEREO

LIGHTING EVALUATION

LANDMARK (LM) TRACKING FOR DESCENT TARGETING I II III

UNKNOWN LM (ULM) TRACK: (INCLUDES PHOTOGRAPHY) II III 30° BEFORE SUB-SOLAR

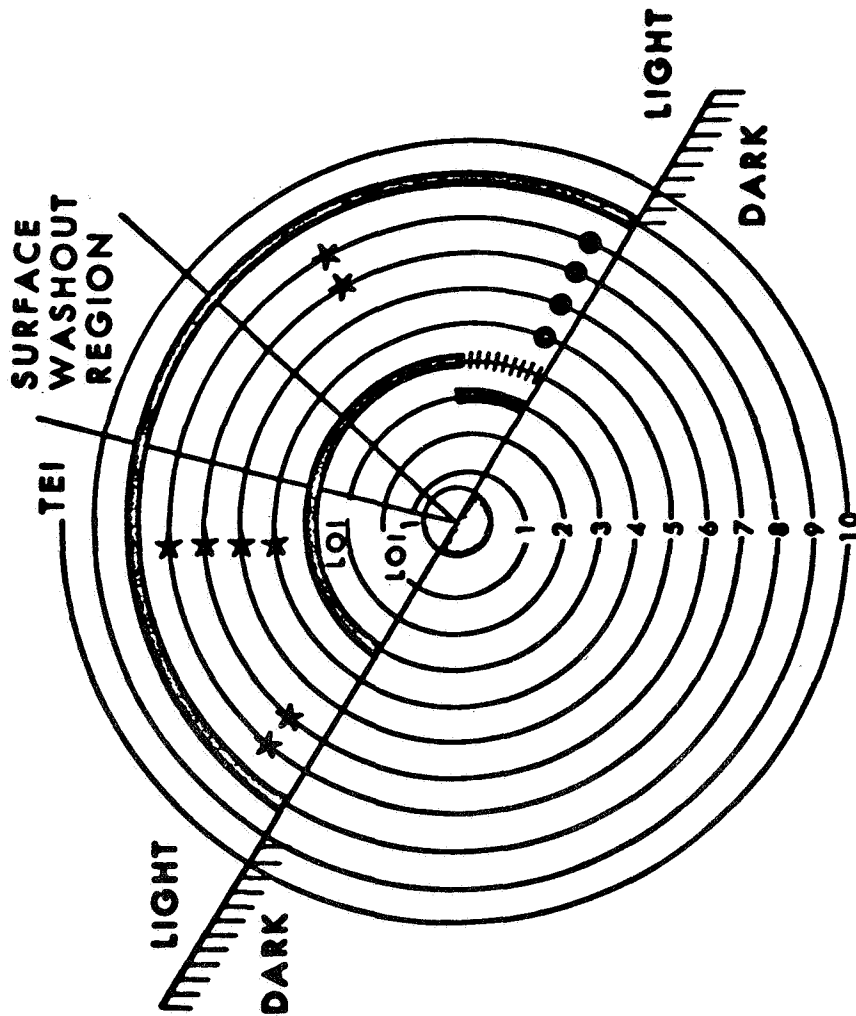
IV 20° AFTER EXIT FROM DARK III 30° AFTER S-SOLAR

OBLIQUE STEREO

UMBRA* SCHEME		
REV	ENTER	EXIT
1	2:22:16:19	2:23:00:16
2	3:08:22:47	3:08:00:40
3	02:22:57	03:08:53
4	04:21:29	05:07:25
5	06:20:02	07:05:39
6	08:18:44	09:04:39
7	10:17:17	11:03:19
8	12:15:51	13:01:47
9	14:14:31	15:00:26
10	16:13:05	16:59:01

\* TIME IN GET BEGINNING AT END OF DAY 2. PENUMBRA IS 13-15 SECONDS DURATION PRIOR TO AND AFTER UMBRA.

# LUNAR ORBIT SC NAVIGATION FOR C' ALTERNATE 1



- LANDMARK TRACKING FOR LM DESCENT TARGETING
- \* UNKNOWN LANDMARK TRACKING
- ||||| LIGHTING EVALUATION
- PHOTOGRAPHY

You recognize, of course, that we stay in the 60-mile orbit throughout.

In general, the first pass, the first active pass here, is taken up with sequential photographs -- that is, photographs wherein we wish to determine what the moon looks like, what our landing sites look like.

We then go into a series of stereo photographs and go on into the mission with some landmark tracking.

We do have at this point-- This is the easternmost Apollo landing site. We do have four separate attempts or four separate times at which we will track the Apollo landing site. We have scheduled also three additional sites on the back side of the moon that we wish to track in order to see what our ability is to track, both to track on board as well as to determine from the ground how good our tracking accuracy is.

We have a number of requests from scientists to conduct some scientific investigations primarily looking at the solar corona, looking at dim sky. Most of these activities take place in these dark periods back here.

In general, the crewmen will be sleeping -- or resting I guess I should say -- in two-hour cycles throughout this period, leading us then to transearth injection at the appropriate time.

I might say right here that we are carrying a number of photographic equipments on board. We have two Hasselblat cameras with a number of rolls of black-and-white and color film, as well as a 16 millimeter (Maurer) camera.

We are planning hopefully -- and I can't tell you precisely when right now -- if the high-gain antenna is up -- to have some periods of TV. And, of course, it will have to be in this general area here in order to get the line of sight back to the earth. We are looking at revs 1, 2 and 9, although I can't specify for you which revolution of those we will select yet.

The lunar orbit phase would be aborted for certain specific losses of equipment, primarily for loss of redundancy



in the guidance and control systems or in the electrical buses or in any of the redundancies on SPS service module propulsion system.

Next slide, please.

Transearth injection, as we said, is nominally at the end of the tenth revolution. We do have the capability to maintain ourselves in lunar orbit for one or two more orbits if there is some overpowering reason for doing so. However, the nominal plan that we will attempt to maintain is to come back at the end of ten revolutions.

We have targeted our landing longitude at 165 degrees west -- that is, almost directly south of Hawaii. And all of our landing zone for all of our liftoff times and all of our liftoff days are on that line. We do not control our latitude until transearth injection. At that point we decide what latitude we will be going to.

We are targeting for the middle of the corridor, and we are targeting for maintaining our capability with a reentry speed.

That other slide just showed we did come back in over Asia.

Next slide, please.

Now, we do, as I said, again have the capability and the probability that we will be conducting midcourse corrections. These again will probably be conducted using the service module reaction control system, and we will direct the trajectory for corridor control only, and we will maintain safe reentry conditions at all times.

Those corrections will be made at the most convenient times, and they will be subject to the same delta-V restrictions I spoke about before.

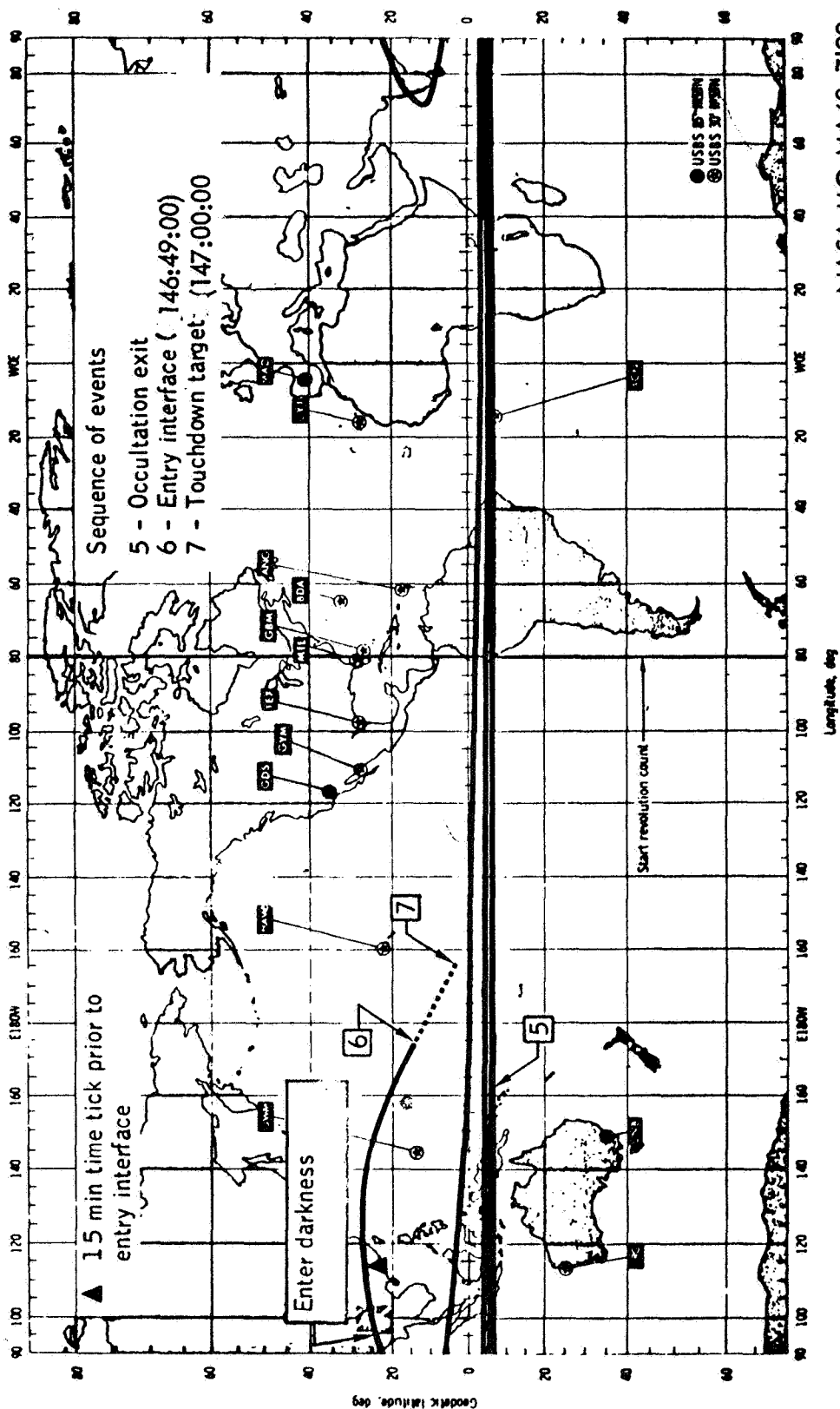
May I have the next slide, please.

Just to give you an idea of what kind of uncertainty we have in reentry flight path angle, this chart was originally set up for one of the longer return times, and for our 50-odd-hour return time you just squeeze it up a little bit.

## **TRANSEARTH INJECTION**

- **NOMINALLY EXECUTED AFTER 10 REVS**
- **TARGETED LANDING LONGITUDE = 165°W**
- **LANDING LATITUDE NOT DIRECTLY CONTROLLED**
- **TARGETED ENTRY PATH ANGLE  $\approx$  -6.5°**
- **RETURN TIME ASAP W/O EXCEEDING  $V_{\text{ENTRY}} = 36\,323 \text{ FPS}$**
- **RETURN INCLINATION  $< 90^\circ$**
- **FIXED ATTITUDE BURN**

# TRANSEARTH COAST

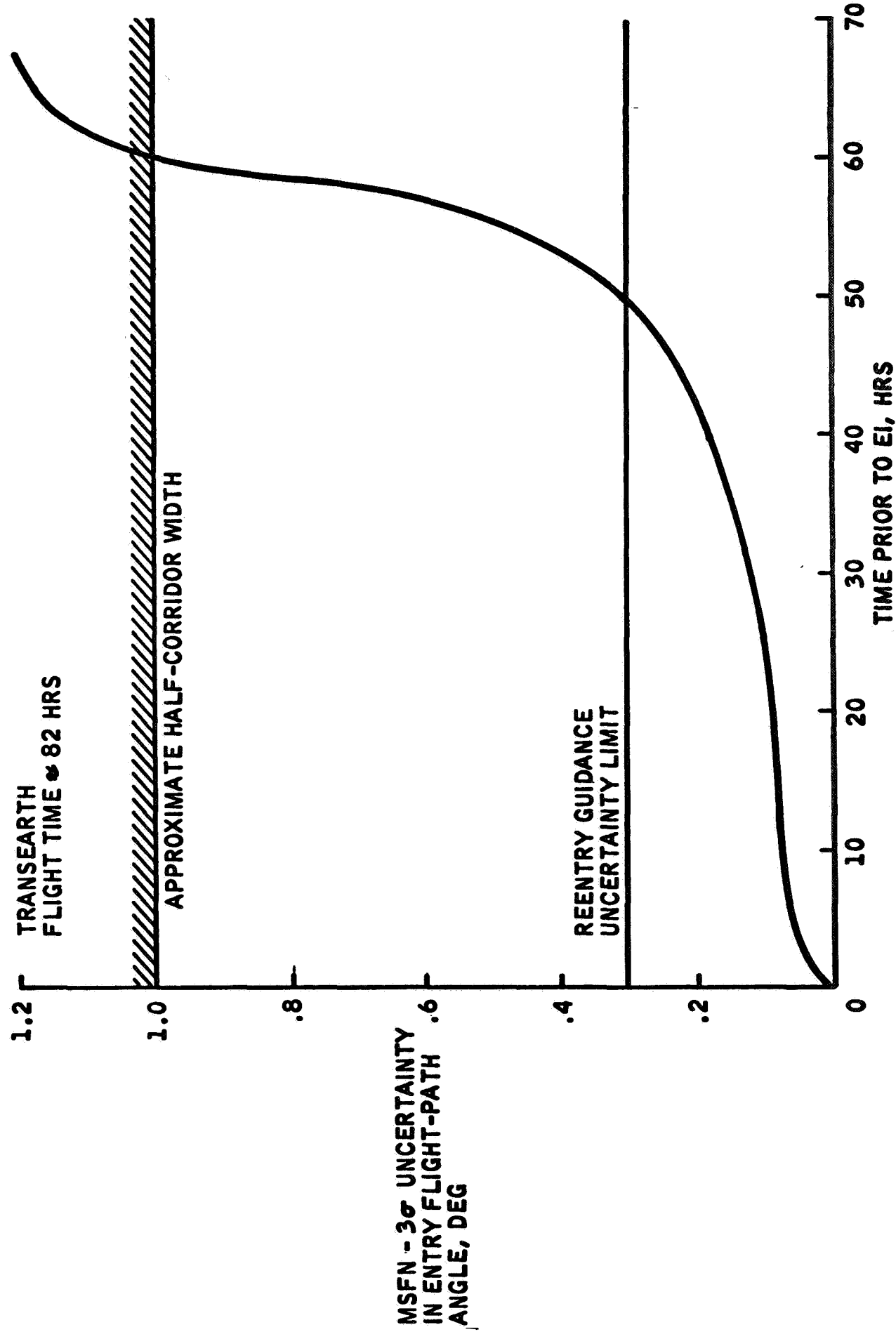


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10-30-68

## **TRANSEARTH MIDCOURSE CORRECTION PHILOSOPHY**

- **CORRECTIONS FOR CORRIDOR CONTROL ONLY**
- **MAINTAIN SAFE ENTRY CONDITIONS WITHIN MSFN UNCERTAINTY**
- **MAKE CORRECTIONS AT CONVENIENT TIMES IF  $\Delta V$  GREATER THAN LOCAL MSFN UNCERTAINTY**

# MSFN - 3σ FLIGHT-PATH UNCERTAINTY AS A FUNCTION OF TIME TO EI.



You can see the manned space flight network itself without any assistance on board will give us a little over a degree of uncertainty at TEI, and this very rapidly converges down to the one degree which we feel is most desirable, very quickly comes down to a very, very nominal level, most satisfactory for reentry.

The spacecraft itself, we believe that is a reentry guidance uncertainty, 3 sigma, of about that order of magnitude (indicating) -- well, within what is necessary. What is necessary is something on the order of a degree.

May I have the next slide, please.

Entry itself looks something like this. This is a slight variation from the skip reentry that you may have been familiar with, in that we are flying what we are calling a constant g reentry. We have decided to use only 1,350 miles of our nominal reentry range, although this range is available to us by our lifting reentry. We did select this short range in order to get this third backup I might say -- mode of constant g.

QUESTION: Is that what we called "footprint" in earlier flights?

SCHNEIDER: Yes. And I will go into that a little bit further.

For weather avoidance, if we are more than one day out we will use our service propulsion system to adjust our nominal reentry point. And if we are less than one day out, we will retarget our entry point and use our footprint for weather avoidance.

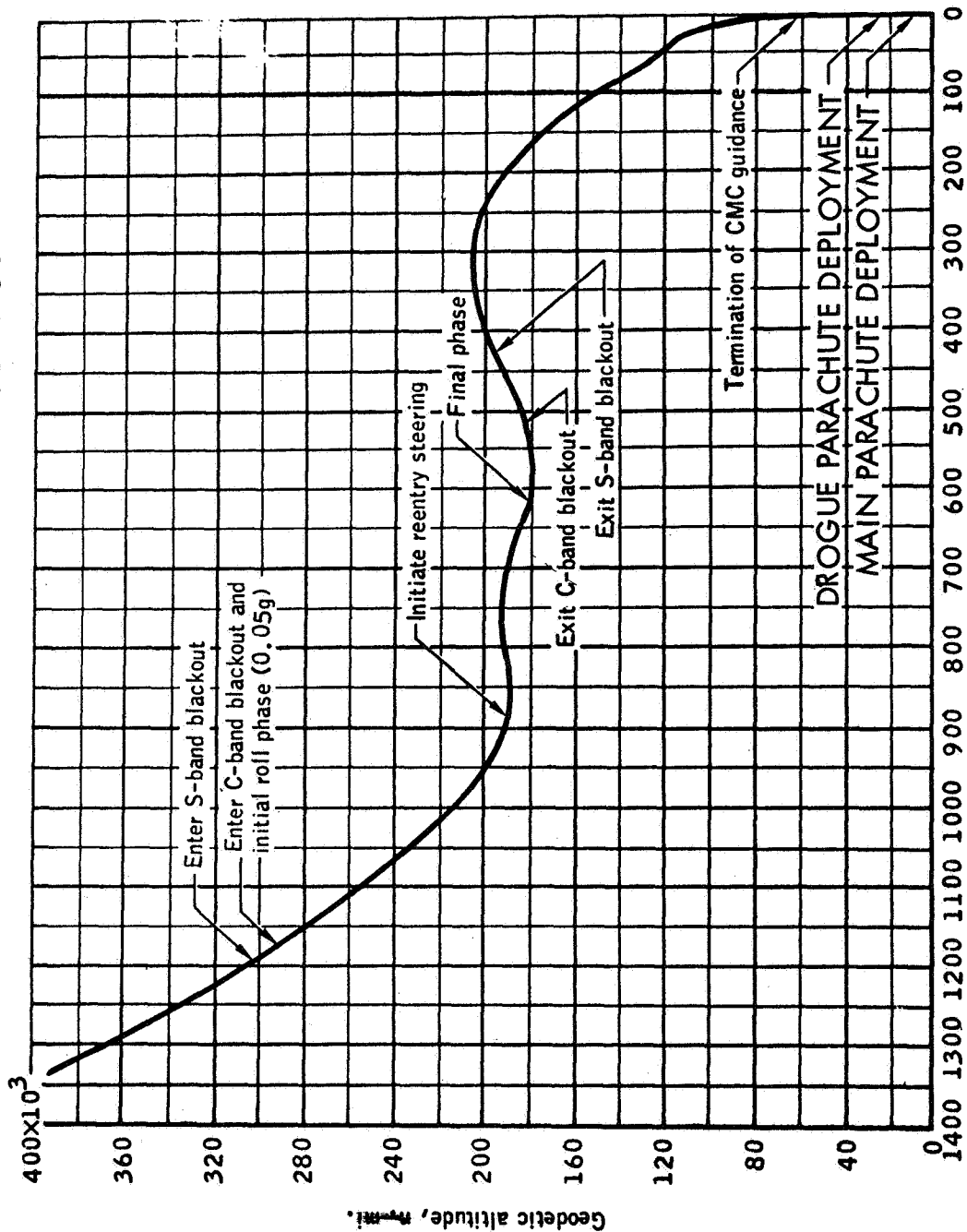
This is what the trajectory will look like. Entry interface at 400,000 feet. And we do enter S-band, we enter the blackout region, and begin flying our constant g reentry.

In contrast to the skip reentry, which would nominally have taken us much further out in the atmosphere and then come back in, we pull this constant 4 g's, and do a little dip, come out of blackout, and then come on back in. This whole activity here takes about 14 or 15 minutes.

## **ENTRY**

- **ENTRY RANGE CAPABILITY - 1200 TO 2500 N. MI.**
- **NOMINAL ENTRY RANGE - 1350 N. MI.**
- **SHORT RANGE SELECTED FOR NOMINAL MISSION BECAUSE:**
  - **RANGE FROM ENTRY TO LANDING CAN BE SAME FOR PRIMARY AND BACKUP CONTROL MODES**
  - **PRIMARY MODE EASIER TO MONITOR WITH SHORT RANGE**
- **WEATHER AVOIDANCE, WITHIN ONE DAY PRIOR TO ENTRY, IS ACHIEVED USING ENTRY RANGING CAPABILITY TO 2500 N. MI.**
- **UP TO ONE DAY PRIOR TO REENTRY USE PROPULSION SYSTEM TO CHARGE LANDING POINT**

# GEODETTIC ALTITUDE VERSUS RANGE TO GO



Range to go, n. mi.

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QUESTION: How many g's, Bill?

SCHNEIDER: About 4 g's scheduled.

One thing I should mention at this point is we are going to give the crew "go" for taking off their suit at injection into orbit, back on one of the earlier slides, and they will conduct the mission, the remainder of the mission, without suits. That is, reentry will be without space suits.

We have provided the crew with heel restraints and also with a head restraint, which, if you recall, were the two areas of concern on Apollo 7.

QUESTION: Does that include reentry then, Bill?

SCHNEIDER: Yes sir.

Next slide, please.

Footprint. This is our reentry coverage. We do come in, as I stated, over Asia. We have very good tracking of Guam. We have stationed a Mercury ship at this point, and then we come down and touch down here. We have the Yorktown in the recovery area.

As I said, recovery is along 165 longitude and for a nominal mission will be approximately at this point (indicating).

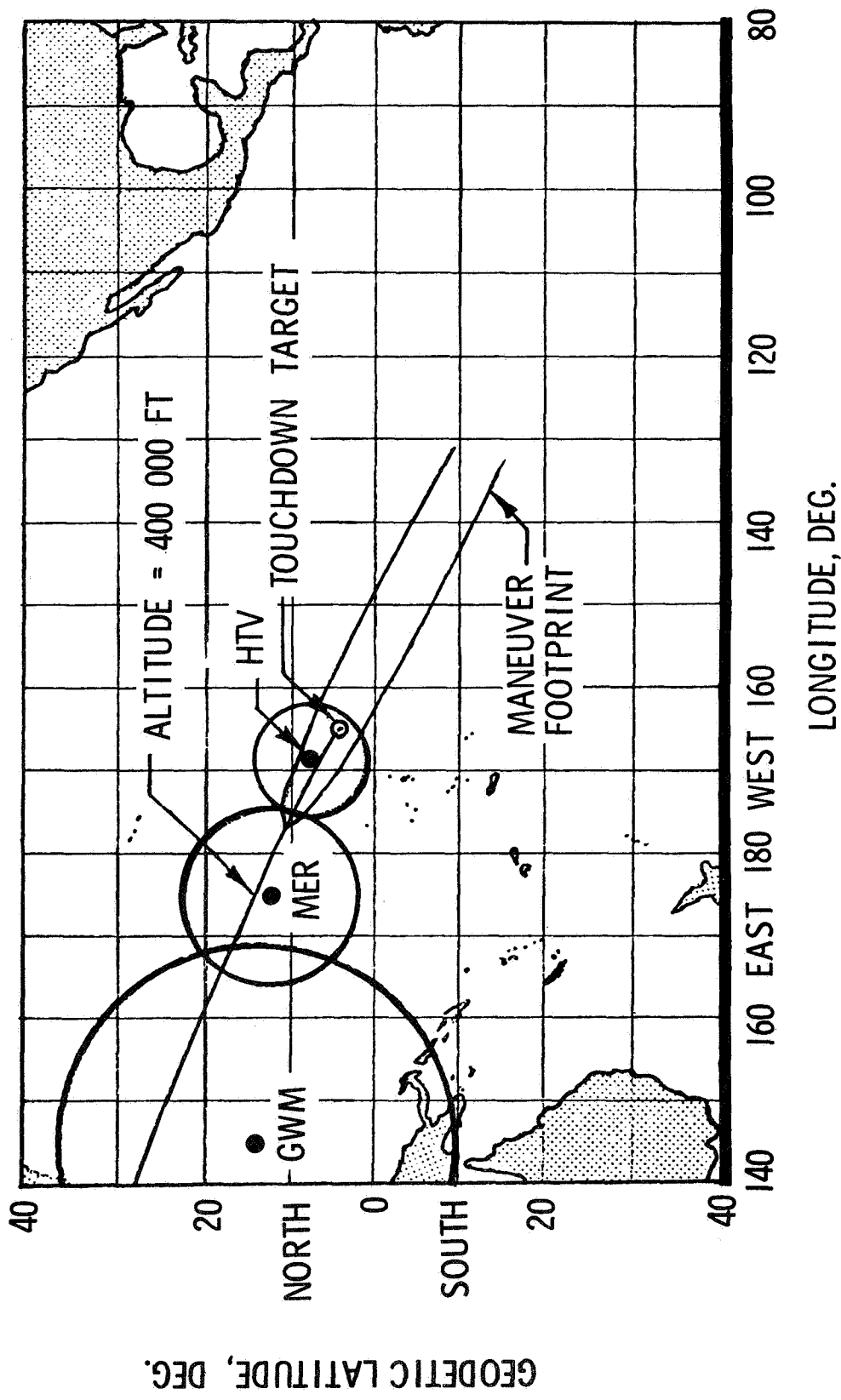
Next slide, please.

I would like to summarize for you the mission by time so that you will get an idea of when things occur. And this slide over here shows the nominal mission times that things will occur, plus delta times, for different liftoff days. That is, nominally, for example, a nominal total mission is six days and four hours approximately. We could conceivably be as long as one day longer or four hours shorter if we lifted off at a different liftoff time.

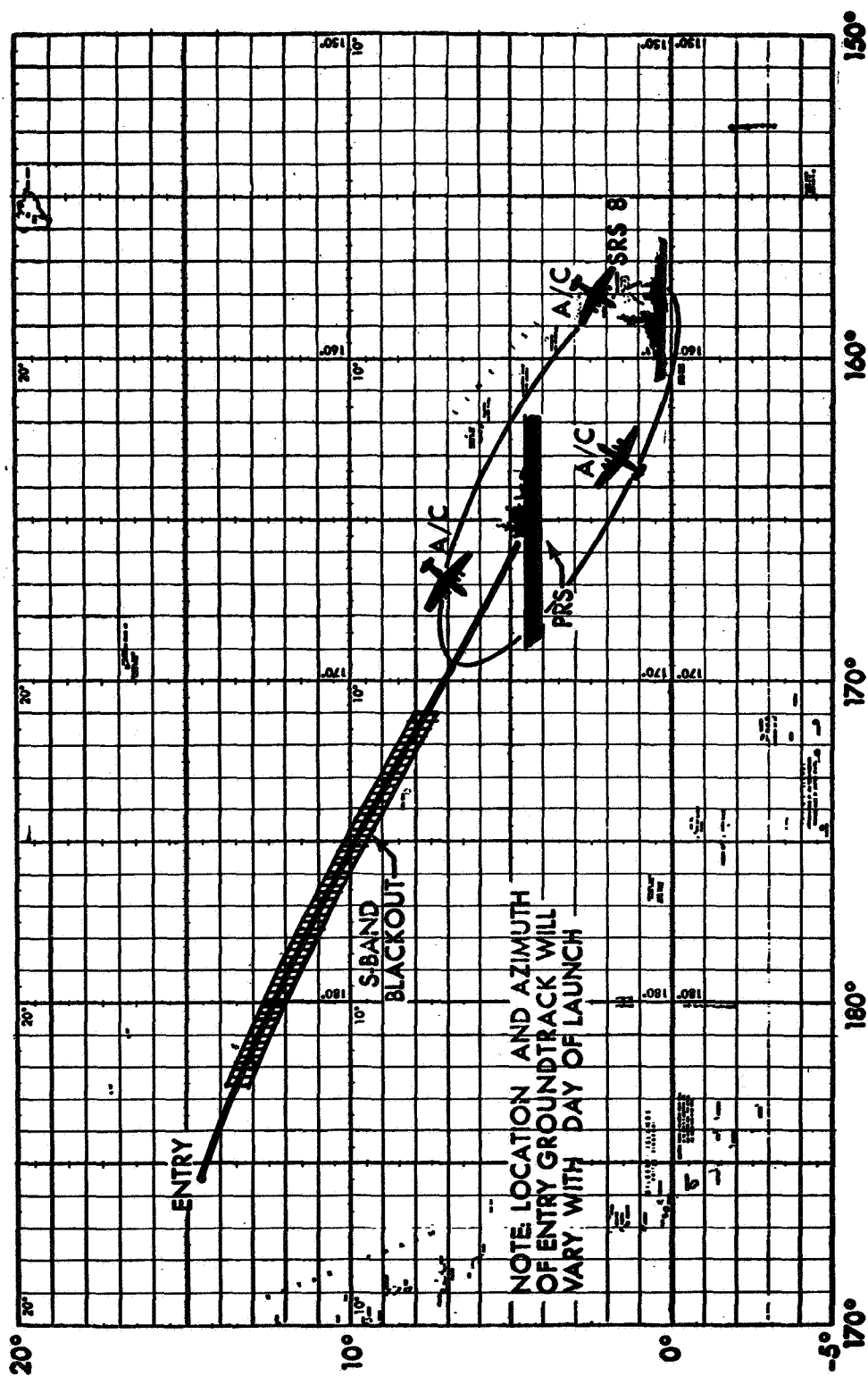
I guess the big numbers to point out are the TLI burn, which is roughly about 311 seconds and stays pretty close to that no matter what our time is, and the free-return circumlunar time, which is another key number, is about 130 hours

# REENTRY COVERAGE

DECEMBER 21, 1968-LAUNCH



# 



# MISSION SUMMARY

DEC 71

EARTH PARKING ORBIT COAST TIME	2 <sup>H</sup> 39 <sup>M</sup> +3 <sup>M</sup> 31
TRANSLUNAR INJECTION BURN DURATION	311.5 <sup>S</sup> +1.8 <sup>S</sup>
TRANSLUNAR FLIGHT TIME	65 <sup>H</sup> +9 <sup>H</sup> -1 <sup>H</sup>
TOTAL FREE-RETURN CIRCUMLUNAR FLIGHT TIME	130 <sup>H</sup> 37 <sup>M</sup> +17 <sup>H</sup> -1 <sup>H</sup>
LOI(1) BURN DURATION	246 <sup>S</sup>
LOI(1) ΔV	2991 FPS +30 FPS -138 FPS
LOI(2) BURN DURATION	9.7 <sup>S</sup>
LOI(2) ΔV	138.5 FPS
TRANSEARTH INJECTION BURN DURATION	206.4 <sup>S</sup> + 35 <sup>S</sup>
TRANSEARTH INJECTION BURN ΔV	3531.7 FPS ± 500 FPS
TRANSEARTH FLIGHT TIME	58 <sup>H</sup> +9 <sup>H</sup> -2 <sup>H</sup>
TOTAL MISSION TIME	6 <sup>D</sup> 4 <sup>H</sup> +1 <sup>D</sup> -4 <sup>H</sup>

and 37 minutes. It can increase some 17 hours or be as little as one hour shorter.

The LOI burn is almost independent of liftoff time. There are some differences because you do a plane correction at that same time, and the plane change does change with lift-off day.

I guess the transearth return time of 58 hours plus nine minus two is the other important point.

Again turning to total delta-V, as far as the launch vehicle is concerned, we have plenty of delta-V available. We use approximately 10,000 feet per second out of the S-IVB for this second, the TLI burn. We have approximately, if I remember correctly, about five seconds of burn left, very comfortable margin.

In the spacecraft, as I say, we expect to do most of our midcourse burns using the SPS system. We have plenty-- I'm sorry. Using the RCS system. We have plenty of SPS system available if we need it in there. We use approximately 7,000 feet per second. We have about 4,000 feet per second floating around, and we haven't used that.

Just to show you where we stand in consumables, may I have the next chart, please?

RCS consumables. Those of you who have been following manned space flight know that consumables have always been something that we have had to play very carefully, and here we have a situation where I think at least in RCS fuel for nominal mission we have very little worry about the fuel quantities. We have available that much, with uncertainties as shown up here, and you can see we probably use about 30 per cent of it.

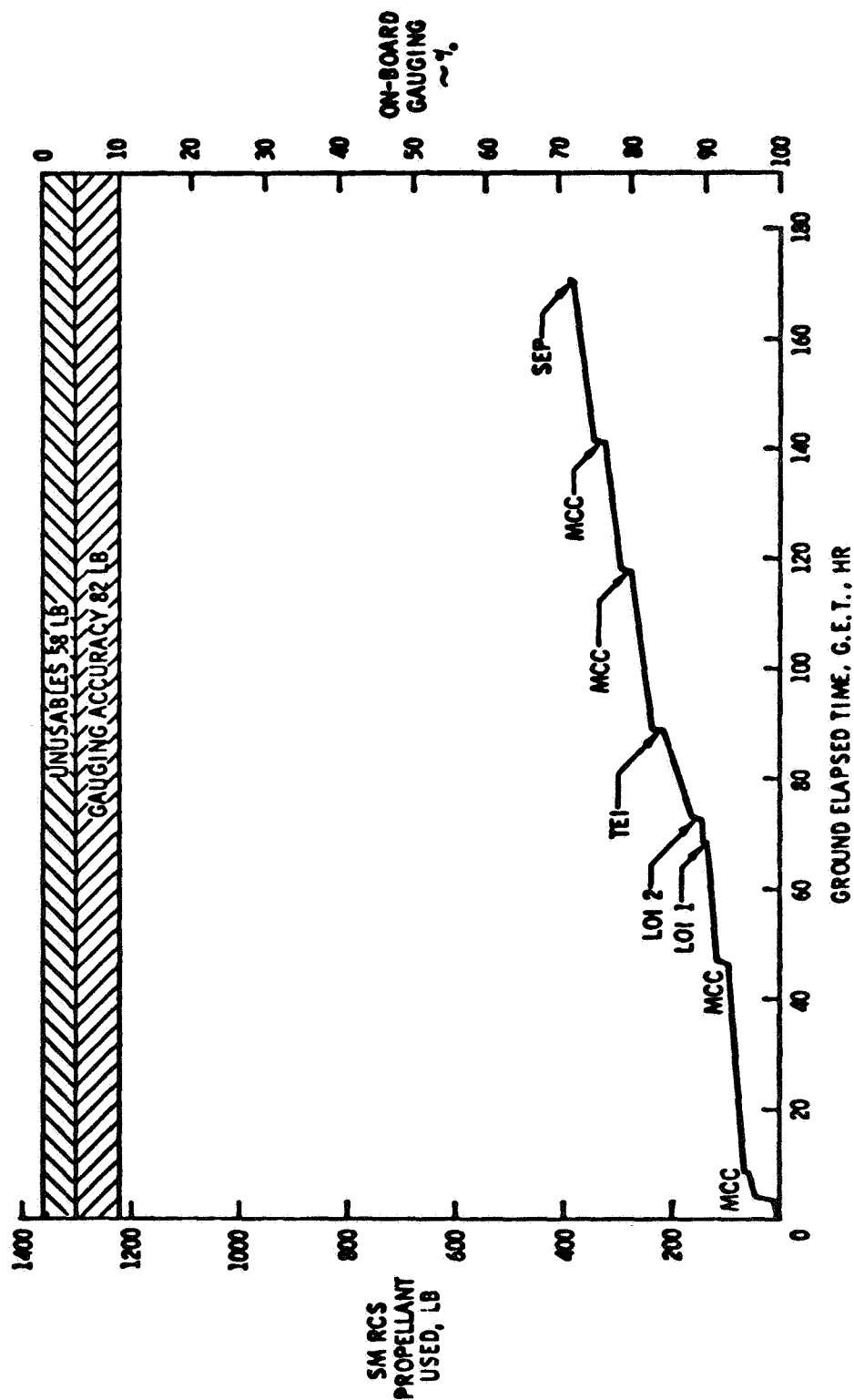
May I have the next slide, please.

The SPS budget runs like this. Beside these, as I said, we have about 4,000 foot per second left over. These are the kinds of dispersions that we anticipate, 3 sigma dispersions. You can see we anticipate about 120 feet per second 3 sigma maximum dispersion for the midcourse corrections.

# APOLLO 8 MANEUVERS AND BURN DURATIONS FLIGHT AZIMUTH - 72°

MANEUVER	GET		$\Delta t$ (SEC)	$V_i$ (fps)	$V_f$ (fps)	$\Delta V$ fps	RESULTANT ORBIT
	(HR:MIN:SEC)						
	START	TERMINATE					
S-IC - CECO OBECO	0:00:00	0:02:06	126	<u>GEOCENTRIC</u>  25,568  ~ 25,584	35,582	+ 9,998	100 x 100 NM
S-II	0:02:33	0:02:31	151				
S-IVB (FIRST)	0:08:44	0:08:70	367				
S-IVB TLI	2:50:31	0:11:21	157				
MCC <sub>1</sub> MCC <sub>2</sub> MCC <sub>3</sub> MCC <sub>4</sub>	TLI + 6 HR TLI + 24 HR LOI - 20 HR LOI - 8 HR	2:55:43	311	<u>SELENOCENTRIC</u>  8,417 5,482 5,345	5,481 5,344 8,865	- 2,936 - 2,990 - 138 + 3,520	LUNAR 170 x 60 NM LUNAR 60 x 60 NM EARTH INTERSECTING
LOI <sub>1</sub>	69:07:29	69:11:35	246				
LOI <sub>2</sub>	73:30:53	73:31:03	10				
TEI	89:15:07	89:18:33	206				
MCC <sub>5</sub> MCC <sub>6</sub> MCC <sub>7</sub>	TEI + HR TEI + 30 HR EI - 2 HR						
ENTRY SPLASHDOWN	~ 146:49:00 ~ 147:00:00						VELOCITY= 36,219 FPS

# C PRIME SM/RCS CONSUMABLES SUMMARY



# PRELIMINARY NON-NOMINAL SPS ΔV BUDGET

●	DISPERSIONS	
●	3σ TRANSLUNAR MCC	110 FPS
●	3σ LOI (1) AND LOI (2)	50 FPS
	TOTAL (RSS)	<u>120 FPS</u>
●	CONTINGENCIES	
●	RETURN ASAP TO ATLANTIC	0 TO 520 FPS (MISSION DEPENDENT)
●	MOVE LANDING PT LONG 20° AT EI -24 HR TO AVOID WEATHER	600 FPS
●	LOSS AT GNCS IN LUNAR ORBIT, I.E. RETURN WITH SCS	120 FPS
	TOTAL (RSS)	<u>625 TO 800 FPS</u> (MISSION DEPENDENT)



And the contingencies we have run like this: 500 feet per second in case we wanted to come home as soon as possible. And we have allotted these amounts of numbers, delta-V's available for weather avoidance and things of that nature.

Out of the 4,000 we again appear to have no problem there.

Looking at the other consumables, electrical power, food and all the rest of it seems in very good shape.

Next slide, please.

One point I would like to make very carefully are the go/no go points that we do have in this mission, and they are listed here, and you can see that we have a number of decision points that will be made, and decision points either to do something or not to do something. And they begin, of course, with our normal go/no go on launch where the Flight Director will be making the usual decisions whether or not we must abort the mission or go into one of the contingency modes.

Then we have our "go" after insertion, which is "go" for the first orbit, and then so on throughout the mission until finally, as I stated, over Australia we do give the "go" for the TLI burn.

We have some very quick decision points that we will make -- namely, one approximately ten minutes after TLI, with a review of that decision about 90 minutes after TLI, for a quick assessment of any dispersions that we may have had, to see if there is any reason for not going on out.

We then have the decision points as stated here for midcourse correction. The first midcourse correction decision point is plus six hours from TLI. And then on here at 24 hours from TLI. And two at LOI minus 20 hours and LOI minus four hours.

In lunar orbit itself we will make a conscious go/no go decision approximately one every hour.

May I have the next slide, please.

GO/NO-GO DECISION POINTS

<u>MISSION PHASE</u>	<u>TIME OF DECISION</u>	<u>REMARKS</u>
LAUNCH	REAL TIME	ORBIT IS "GC" IF H <sub>p</sub> 275 NM
EARTH ORBIT	AFTER INSERTION	UNTIL LANDING AREA 2-1
	~ REV 1 U.S. PASS	TO TLI
	CRO	FOR TLI BURN
TRANSLUNAR (CONTINUOUS MONITORING)	~ TLI +10 -90 MINUTES	FOR ANY DISPERSIONS AND SEPARATION MANEUVER
	~ TLI + 2HR.	TO TLI +4HR.
	TLI + 4HR.	STILL PERFORM EARTH ORBITAL TYPE MISSION
	TLI + 5HR.	DEPENDENT UPON $\Delta V$ REQUIREMENTS FOR MID-
		COURSE CORRECTION: (1) CONTINUE MISSION
		(2) LUNAR FLYBY
	TLI + 6HR.	FOR MCC <sub>1</sub>
	$\Delta V$ 4500 FPS TO PTP'S	FOR ANY MALFUNCTIONS THAT REQUIRE EARLY RETURNS
	TLI + 24HR.	FOR MCC <sub>2</sub>
	LOI - 20HR.	FOR MCC <sub>3</sub>
	LOI - 8HR.	FOR MCC <sub>4</sub>
LUNAR ORBIT	LOI <sub>1</sub> - 1HR.	FOR LOI BURN: AT LEAST 4HR. LUNAR ORBIT
		CAPABILITY.
	LOI <sub>2</sub> - 1HR.	FOR LOI CIRCULARIZATION BURN. 4HR ORBIT
		CAPABILITY.
	TEI - 1HR.	CONTINUOUS MONITORING WHILE IN VIEW FOR
		TRANS EARTH INJECTION BURN.

I did touch on the alternate missions as I went through. I would like to quickly run through the facts that we do have preplanned alternate missions, and basically we have established a philosophy that says we can do these preplanned alternates with a minimum of additional work and also to get a maximum of return to the program. And these are the guidelines that led us up to -- if I might have the next slide -- decision to come up with these alternate missions.

If we have an early separation for the S-IVB during the first insertion into orbit burn, we will in general revert to an earth orbital mission.

If we have enough SPS fuel on board, we will try to go for a 4,000 mile ellipse. And that will be a real-time decision depending upon what kind of delta-V we have had to use in order to get into orbit.

If we have no S-IVB injection burn -- that is, the S-IVB first burn was satisfactory but for some reason or other we inhibit the second burn of the S-IVB -- we will use the spacecraft SPS to put us into a high-apogee orbit and remain in that orbit for two to four revolutions and then come back down and basically do a maximum ten-day duration mission -- that is, repeat those elements of the C mission that we feel necessary to do at that time.

If we have an early cutoff of the S-IVB -- that is, the S-IVB begins to burn but for some reason or other we are forced to cut it off or it cuts off itself -- we have a number of mission alternatives which basically say we'll take advantage of whatever altitude we have.

If we are in this range here up to 4,000 miles, we go into the high apogee. If we are 4,000 to 22,000 miles, we will have to come back in as soon as we can-- I'm sorry, if we are 22,000 to 60,000, we will have to come back in on a direct reentry. We don't have enough SPS to do anything different.

If we are over 60,000, we will have to come back in on a direct reentry. We don't have enough SPS to do anything different.

If we are over 60,000 miles, we will do a circum-lunar flyby.

## APOLLO 8

### ALTERNATE MISSION PLANNING

#### PHILOSOPHY:

1. MINIMUM CREW TRAINING REQUIRED
2. NO ADDITIONAL COMPUTER SUPPORT REQUIRED
3. MSFN COVERAGE OF SPS DEBOOST MANEUVERS
4. WATER LANDING DURING DAYLIGHT
5. ALL HIGH ELLIPSE MANEUVERS TO BE RETROGRADE
6. ADHERE TO LUNAR MISSION TIMELINE IF POSSIBLE
7. MAINTAIN RCS DEORBIT CAPABILITY

# ALTERNATE PLANS SUMMARY

CASE	SUMMARY PLAN
<p>A. EARLY SEPARATION FROM S-IVB DURING INSERTION BURN.</p> <p>B. NO S-IVB INJECTION BURN</p> <p>C. INADVERTENT S-IVB TLI BURN CUTOFF</p> <p>1. APOGEE 100-4,000 NM</p> <p>2. APOGEE 4,000-22,000 NM</p> <p>3. APOGEE 22,000-60,000 NM</p> <p>4. APOGEE &gt; 60,000 NM</p>	<p>A. 1. IF LESS THAN 900 FPS SPS <math>\Delta V</math> REQUIRED TO INSERT INTO ORBIT THEN BURN SPS AT APPROPRIATE TIME FOR 4000 NM ELLIPSE.</p> <p>A. 2. IF GREATER THAN 900 FPS SPS <math>\Delta V</math> WAS REQUIRED FOR INSERTION THEN REMAIN IN EARTH ORBIT (10 DAYS IN DURATION).</p> <p>B. 1. BURN SPS AT APPROPRIATE TIME TO RAISE APOGEE TO 4,000 NM. SPACECRAFT TO REMAIN IN THIS ORBIT FOR 2-3-4 REVOLUTIONS.</p> <p>B. 2. FLY EARTH ORBIT MISSION OF 10 DAYS DURATION.</p> <p>C. 1. RESHAPE ELLIPSE TO 4,000 NM APOGEE. BURN SPS AT APPROPRIATE TIME OVER GROUND STATION, 2-4 REVOLUTIONS IN HIGH ORBIT.</p> <p>C. 2. PERFORM PHASING MANEUVER AT FIRST PERIGEE TO PLACE LATER PERIGEE OVER A MSFN SITE. AT THAT PERIGEE PERFORM DEBOOST TO 400 NM. LATER PERFORM SECOND SPS MANEUVER TO AGAIN LOWER APOGEE AND PERFORM LOW EARTH ORBITAL MISSION.</p> <p>C. 3. REMAIN ON ESTABLISHED TRAJECTORY AND PERFORM DIRECT ENTRY. (INSUFFICIENT SPS FOR DEBOOST TO 400 NM AND THEN DEORBIT).</p> <p>C. 4. PERFORM CIRCUMLUNAR FLY-BY USING SPS TO ATTEMPT TO CORRECT BACK TO THE FREE RETURN TRAJECTORY.</p>

Again, all of these alternate plans will be real-time decisions, and the decision as to which one we will exercise or whether or not we will exercise it will be dependent upon the circumstances at that moment.

However, we do have these alternates available.

May I have the next slide, please.

Just a brief reminder as to who the crew is. Frank Borman, Jim Lovell, and Anders. Backup crew: Armstrong, Aldrin and Fred Haise.

In addition to those you will see the normal cast of characters at the Cape and at Houston:

Rocco (Petrone) is again the Launch Director at KSC where all the activity is for the next month and a half or so, and he is backed up by Paul Donnelly, Launch Operations Manager.

Chris Kraft, the Director of Flight Operations at Houston, has nominated Cliff Charlesworth as the primary Flight Director on this flight. He will be backed up by Glen (Lundy) and also by a new Flight Director, (Milt Lindler).

The Department of Defense recovery forces and support forces are headed up by General (Vince Huston). The DOD manager for manned space flight will be backed up by Rear Admiral (Bacudas) who is the Commander of Task Force 130, Primary Recovery Force.

Admiral (McManus) will head up Task Force 140 in the eastern recovery forces, with General Jones, Davy Jones, heading up the Eastern Test Range.

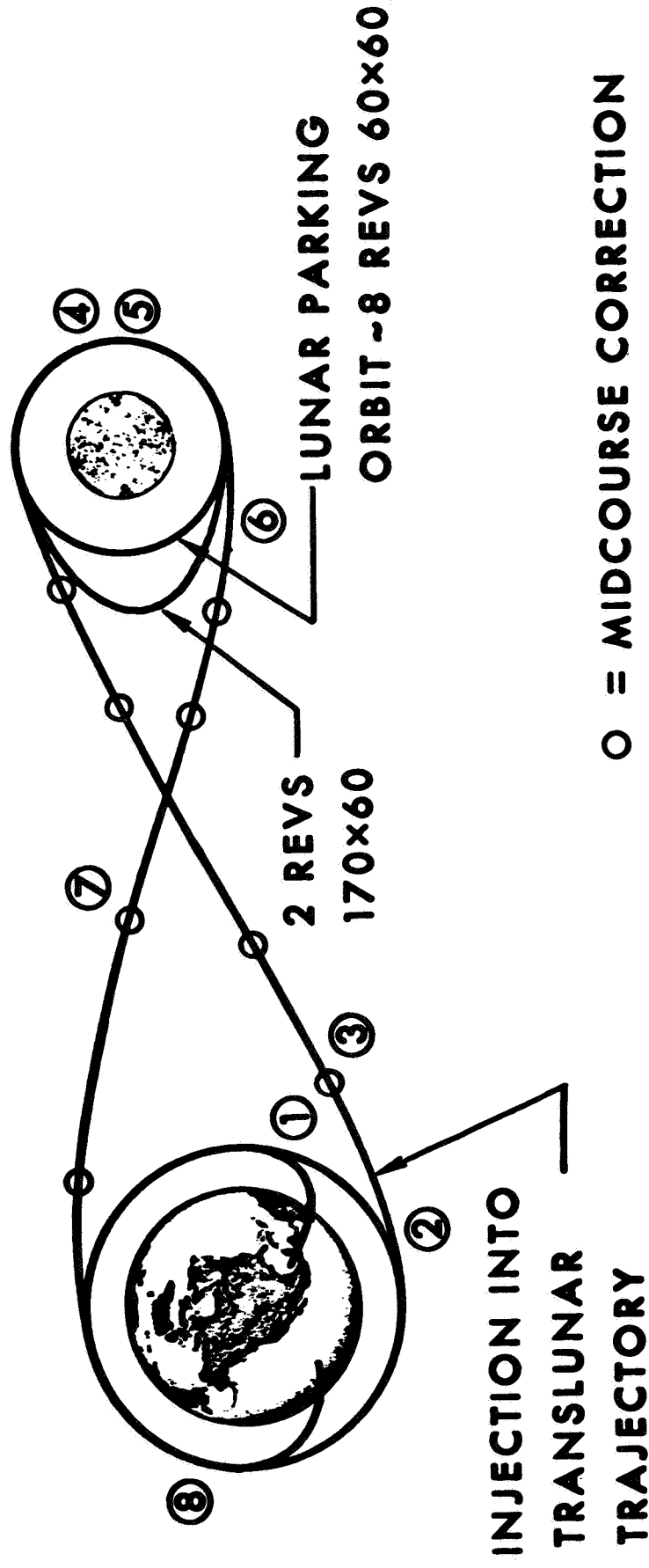
The recovery vessel, as I said, is the YORKTOWN.

Thank you.

QUESTION: On that alternate mission, the circum-lunar, how far out conceivably could they go? They go beyond the moon and how much farther beyond?

SCHNEIDER: We'd be targeting for 60 nautical miles around the moon.

# MISSION PROFILE



# APOLLO 8 PRIMARY FLIGHT CREW



NAME	BORMAN	LOVELL	ANDERS
AGE	40	40	35
ASSIGNMENT	COMMANDER	COMMAND MODULE PILOT	LUNAR MODULE PILOT
TECHNICAL SPECIALTIES	B.S. DEGREE-U.S. MILITARY ACADEMY 1960, M.S. DEGREE (AERONAUTICS) CALIFORNIA INSTITUTE OF TECHNOLOGY, BACKUP COMMAND PILOT GEMINI 4, COMMAND PILOT GEMINI 7.	B.S. DEGREE-U.S. NAVAL ACADEMY 1952, BACKUP PILOT GEMINI 4, PILOT GEMINI 7, BACKUP COMMAND PILOT GEMINI 9, COMMAND PILOT GEMINI 12.	B.S. DEGREE-U.S. NAVAL ACADEMY 1955, M.S. DEGREE (NUCLEAR ENG.) AF INSTITUTE OF TECHNOLOGY, BACKUP PILOT GEMINI 11
TOTAL FLIGHT TIME	5441	4173	3218
TOTAL DT TIME	4234	2899	2584
RANK	COLONEL (USAF)	CAPTAIN (USN)	MAJOR (USAF)



QUESTION: Just 60 miles farther than the moon?

SCHNEIDER: Yes.

QUESTION: Bill, this is going to be shirtsleeve all the way?

SCHNEIDER: Except for the liftoff phase. We go for insertion. There is a checklist, and at the same time that they are given a "go" for insertion we will give them a "go" for taking the suits off at the same time, contingent upon the same ground rules that we had on Apollo 7.

ALIBRANDO: Dr. Paine has to leave in a few moment, so if there are any questions you wish to direct to him, we will take those first.

Okay. Does anyone have a question for Dr. Paine?

Bill Hines.

QUESTION: Yes. Dr. Paine, we have heard that this was in the thinking stage and in the review stage for a long, long time, and so forth, but when did you really make up your mind that this was "go"?

PAINE: Final decision was made yesterday afternoon about four o'clock, Bill.

QUESTION: What sort of a meeting did you have just prior to that?

PAINE: This was actually the climax of a series of meetings. The meeting yesterday was a rather large meeting involving the entire executive establishment at NASA, both manned and unmanned, and that was followed by a smaller meeting in which we had the top people in Manned Space Flight, and George Mueller, Wernher Von Braun, the Center Directors, and several of our consultants, Tommy Thompson, Eberhart Reese, and the decision was made at the conclusion of that meeting by Dr. Mueller and myself and our Associate Administrator, Homer Newell.

QUESTION: How was that made? By the three of you voting? Or by a consensus? What was the mechanism for the final decision?

PAINE: It was actually a vote, although the recommendations in all three meetings were unanimous to go for the lunar orbiter mission on Apollo 8.

QUESTION: Dr. Paine, has President Johnson and President-Elect Nixon-- Have they been told and/or were they consulted before the decision?

PAINE: Yes, they were informed yesterday at noon after the decision was made.

QUESTION: Just for the record, was that vote unanimous?

PAINE: Yes.

ALIBRANDO: Any more questions for Dr. Paine?

QUESTION: Yes. In view of Zond 6 and whatever else you may know about the Russian program, how do you feel now about our chances of being around the moon before they are?

PAINE: I really don't know whether the Russians are going to make a manned circumlunar attempt before December or not. This did not play any part at all in our decision on this flight.

QUESTION: Since the earliest days of this program there was always a plan to carry the lunar excursion module on any mission which would involve a commitment for lunar orbit on the theory that you could use the engines of the LM system, in case of one of these service propulsion module breakdowns, to drive the spacecraft back home.

Now you are going to commit the astronauts to lunar orbit without a functional LM. Could you tell us why you think that we should do this in December, when if we waited until next spring we would have a LM and we would not be putting these astronauts in this position where they have no redundancy for their service propulsion engine?

PAINE: I believe that was adequately covered in our presentations. We feel that the backup systems' redundancy and the plateau manner in which we are undertaking this mission, on a step-by-step basis, give us a great deal of

assurance, and that, as a matter of fact, I believe that we actually have more assurance without flying the LM out to the moon on this mission, with all the additional power that this gives us on our consumables, so that we feel that at this time we are ready for the mission and that this will be within the normal hazards of test pilots flying experimental craft.

QUESTION FROM HOUSTON: In the event that you did have reason to believe that the Soviet Union was going to fly a manned lunar flight in December about the same time we are trying to do so, or in the event that they did start one just prior to the time we plan to start one, would this have any impact on our own flight?

PAINE: No.

ALIBRANDO: We will proceed with questions from here.

QUESTION: Dr. Paine, can this mission now be considered to take the place of the F Mission?

ALIBRANDO: Dr. Paine has left.

We are going to proceed with questions from Washington.

QUESTION: General Phillips, if you are ready, you are probably the most prominent systems integration manager we have, and I am sure that you play the odds a good bit. What do you think the odds are of the full lunar orbit mission to be completed successfully?

PHILLIPS: I'm not going to try to calculate a set of probability numbers or odds for you. I feel that we're ready for lunar orbit mission and that we have every reason to expect that we will be able to carry out the full mission and to succeed with it. If I wasn't convinced of that, I wouldn't have recommended such a mission in the first place.

QUESTION: One other question is how near to full space simulation do you achieve on earth with all of this SPS testing? What is the closest you think you get in earth testing on the SPS to simulate the space environment?

PHILLIPS: Well, with most of our systems and with the SPS in particular, we are able to simulate the environs on earth with one important exception, and that's zero g flight of any significant duration.

As you know, we can simulate zero g flight for only a matter of several seconds by 135 aircraft, and up to about 30 seconds of zero g flight has been performed. Of course, we can't test propulsion systems in that environment.

Except for the zero g environment, we are able to simulate all of the important environments I think rather well.

QUESTION: Would you please share your opinion on Zone 6 with us? And could it be that it is just a repetition of No. 5?

PHILLIPS: I don't believe I know any more about Zond 6 than you do from having read the news accounts. The news accounts say that it is an unmanned probe likely to be a flight similar to Zond 5. I really don't know any more about it than that.

QUESTION: When you make this accelerated return, this 58-hour -- or is it 55-hour return-- Now, as I understood one of you gentlemen to say, are you going to be burning your SPS engines to get this quick return? And what does this do to your speed, to your translunar -- coming back to earth speed?

PHILLIPS: Well, the return to earth, coming out of lunar orbit-- The energy is added by the service propulsion system engine. In other words, you can find yourself in lunar orbit and the spacecraft propulsion system, the service propulsion system so-called, is burned to add approximately 3,000 feet per second to your velocity in lunar orbit, which adds the energy that takes you on the way back to earth.

The duration of that burn and therefore the energy added, the number of feet per second that is added to velocity, plays the biggest part in determining the return time.

A shorter burn would provide a longer return time, and an even longer burn than we plan would accomplish a shorter return time.

The nominal return time, if we get off on time on this mission, is very close to 58 hours. And the reentry velocity that that burn provides is about 36,300 feet per second.

QUESTION: Well, now, on your return time, is it going to be 55 hours or 58 hours?

PHILLIPS: The nominal return time, if we get off at 0745 the morning of the 21st-- The return time I think in detail is 57.8 hours. So I have said approximately 58. It is a few minutes short of 58 hours.

QUESTION: Now, if you didn't burn your SPS, you would be in a roughly 80-hour or 88-hour return time, wouldn't you, and after you leave lunar trajectory or lunar orbit you would more or less be going about 3,500 miles per hour until you get in pretty close to the earth and the gravity started pulling you in there?

Now, in this long haul between the moon and near earth, do you know what in miles per hour your speed is going to increase to?

PHILLIPS: Yes. I haven't really broken it down in my own mind in statute miles per hour. We tend to make most of our measurements in feet per second.

We enter the earth's atmosphere at about 400,000 feet at a velocity of about 36,300 feet per second. Now, if somebody can tell you what that is in statute miles per hour-- I think it's about 25,500 statute miles per hour.

We leave the moon's orbit -- in other words, the burn that we make to the so-called transearth injection -- puts us at a velocity-- I think we have got it on a table here. I just don't have the figure in my head.

SCHNEIDER: You go on to something else and I'll get it.

PHILLIPS: Let us look that up and come back.

ALIBRANDO: Can we have another question?

QUESTION: How much faster will they be reentering than they would if they took the long trip back, the slower trip back?

PHILLIPS: Well, it is a few hundred feet per second. If you come back in say 90 hours, which is a very long return option, your reentry velocity is of the order of 35,700 feet per second. If you come back in like 55 hours, which is a little faster than we are planning to come back, you would be at like 36,400 feet per second.

So you vary over a few hundred feet per second in this particular time regime.

QUESTION: And you can still fly a constant g coming down?

PHILLIPS: Yes.

QUESTION: So you are not overloading them because of this different speed?

PHILLIPS: No. Under any of the velocity conditions that we would expect to encounter, we plan the 4 g, constant g, reentry deceleration.

SCHNEIDER: I guess I should state that the reentry path that we are flying was always one that we may have found ourselves in if that's what the computer had called for. It is just that's the one we are targeting for at this time.

In response to the question of what our velocity is after your transearth injection burn, nominally it will be 8,865 feet per second after we have added the 3,520 foot per second burn on with our SPS. Of course, then our reentry speed of 36,300.

QUESTION: General Phillips, getting into the area of risk again, can you get into the matter of at the end of the flight if you miss the window can you tell us what happens?

PHILLIPS: The question is if we miss our launch window what happens? As was described here, the launch window, which is set by --

QUESTION: I mean the reentry window. In other words, if you bounce out or if you fail to come in in this corridor, what happens?

PHILLIPS: All right. The question, a little different, is if we miss the reentry corridor. The corridor is set on the upper limit or the high side by the skip-out boundary, and if we miss the corridor on the high side and in fact skip out, then it's a spacecraft and crew loss kind of situation.

The trajectory that the spacecraft will follow if it did skip out is a large ellipse, a large elliptical trajectory around the earth, and the time back to earth is a matter of several hours depending on the details of the condition or the situation. And there is not sufficient electric power nor oxygen on board the command module, because you no longer have the service module with you at that point to sustain life nor to provide for a subsequent reentry.

The lower limit of the corridor is set by the high deceleration limit that the spacecraft would be subjected to if it came in too steeply. And if the spacecraft entered below the low side of the corridor, the decelerations would exceed about 20 g's. The heating rates will be in excess of those for which the spacecraft was designed, and there would be a structural breakup and loss of the spacecraft and the crew.

These reentry conditions in this corridor have been defined and described going way back early into the program. This reentry corridor was used on the Saturn V flights, 501 and 502, because, if you will recall, there we boosted the spacecraft up to an apogee of about 11,000 miles, and it was necessary for the spacecraft with its on-board guidance and navigation equipment to enter within that corridor or it would have experienced the same things that I have described here.

Bill showed a couple of curves that showed what we have determined from our analysis and test work is the capability to hit that corridor. We don't feel that in this respect there is really any risk.

QUESTION: I believe the mean distance of the moon to the earth is about 238,000 miles. On this flight will the

moon be on the close side or the far side of that mean distance? And does that distance have any weight in your determination for the December 21 launch?

PHILLIPS: The distance of the earth-moon system is not a primary deciding factor on the launch window. The deciding factors on the launch window are the lighting conditions at the Apollo landing site over which we intend to fly where we want lighting angles of approximately or less than seven degrees, by a requirement for a daylight launch, the requirement for a daylight recovery. And all of these conditions taken together set up the time of the window that we have established.

The distance between the earth and the moon is incidental in this set of calculations.

QUESTION: Do you have there a figure for the elapsed time from lunar injection from earth orbit until the time you arrive in lunar orbit approximately?

SCHNEIDER: Was that from TLI to LOI?

QUESTION: Right.

SCHNEIDER: You can do some subtraction. TLI ends at 2 plus 55, and LOI 1 begins at 69 plus 11.

QUESTION: If this flight is completely successful, how much time could it save you in your scheduling?

PHILLIPS: Well, the question is if the flight is completely successful how much time can this save us in our schedule? That's a hard question to answer in absolute terms. The mission sequence that we now plan is this C-prime lunar orbit mission on Apollo 8, the so-called D mission on Apollo 9 -- this is 504, Spacecraft 104, and LM 3, which will put the entire spacecraft including the lunar module into earth orbit for exercising all of its systems. Now, beyond the D mission, we plan for an F mission, which is a lunar orbit mission with the entire spacecraft, including the lunar module, including a descent to about 50,000 feet, but not a landing, rendezvous and return to earth.

And beyond that we feel that we'll be prepared for the lunar landing itself.



So I think the minimum sequence ahead is C-prime, D, F, and then a lunar landing. That is the minimum sequence.

Now, each flight, depending on exactly how it goes, will have a definite bearing on the requirement for subsequent operations. We are prepared to conduct more than one flight of the combined spacecrafts SM and LM in earth orbit if our experience up through the D mission were to indicate the necessity or desirability of doing that.

Let me point out one other thing. In the weeks since the middle of August when we set out on the present course for the C-prime mission, we have evaluated our mission sequence to consider those objectives that we can accomplish in C-prime, D, F and the lunar landing itself, and have decided on the basis of that consideration that we will not plan in our mainline mission sequence to fly the mission we used to call a E mission.

You will recall that the E mission was a mission in which the Saturn V boosts the entire spacecraft into earth orbit, and then the translunar injection boosts the entire spacecraft into an apogee of around 4,000 miles, where in three or four orbits to that altitude we would conduct several evaluations involving the space maneuvers and the command service module LM operations independently and together.

We have through evaluating and considering the objectives we can accomplish on C-prime, those that we can reprogram to F or to lunar mission itself, concluded that we will not require an E mission.

I don't want to leap to the conclusion that C-prime substitutes for E, because it does not in its totality. C-prime will accomplish certain of the objectives that we had planned for E. It will accomplish certain of the objectives which without it we would not have accomplished until F.

Adding up all of these things together has led us to lay out a mainline mission sequence -- C-prime, D, F, lunar landing -- as the minimum sequence.

So, when you take all this together, you can say that we have subtracted one mission from the previously

planned sequence, the E mission, added another which is the C-prime, but they are not directly a one-for-one tradeoff. Other swaps of objectives were involved in the total process.

Now, if I could just say one more word, I feel with the technical and operational experience that we will get on the C-prime lunar orbit mission that we will, in fact, have shortened the time to a manned lunar landing by a measurable amount, but it's very difficult to demonstrate that in terms of days or weeks or months or discrete missions plus or minus.

QUESTION: General Phillips, presuming you get off on schedule on December 21, what will be the distance of the moon from the earth at the point of lunar orbit insertion? And will the moon be going away from the earth or heading toward it?

PHILLIPS: Well, the question is how far will the moon be from the earth at the time of lunar orbit insertion if we get off on time? And I'm going to have to get somebody to look at a chart and figure that out.

SCHNEIDER: I'll give you that afterwards.

QUESTION: General Phillips, some Russian scientists have said they prefer to see an animal go around the moon before permitting manned flight in order to check on radiation levels once again. Is radiation, either local or solar, a specific risk in this mission?

PHILLIPS: Well, the question bears on the radiation levels to be expected in this flight and the necessity for an animal flight to precede.

We have a great deal of information, all that we believe we need to understand the radiation environment of the earth-moon system, and these radiation environments have been taken into account in the design of our equipment.

The command module, for example, provides a very good shield against radiation, and as you pass through the so-called Van Allen belts around the earth, for example, where the radiation levels are fairly high, the command module by reason of the structure and its heat shield insures that

crew is exposed to only very, very small amounts of radiation.

The radiation in free space and in the vicinity of the moon is well understood. We know what the numbers are. There has been much attention over the years to the possibility of solar flares, which is in some senses a predictable and in some senses an unpredictable source of high levels of radiation energy.

Between NASA and ESSA, over recent years and months, we have developed all of the predictive techniques that we think are required to provide for warning of radiation levels from solar flares that would cause one to do anything differently finding himself out in deep space.

All of the energy levels that are concerned with solar flares are of concern if you find yourself outside of the spacecraft or in a thin spacecraft such as the lunar module. Those to which the crew would be exposed in a command module are not really of concern.

So I guess the brief answer is we understand the environment, our system has provided for predictive techniques with sufficient warning time of solar flare events, and we don't feel that it's necessary for animal type flight to in any way evaluate the environment.

QUESTION: Bill Schneider, could you tell us what the orbital speed around the moon will be and at orbital altitude above the moon what will it look like to the three crew members -- the moon, that is?

SCHNEIDER: The orbital speed is about 5,300 feet per second around the moon. I don't know what it will look like. That's one of the reasons we are sending them out there. Other than I suspect it will look like the Lunar Orbiter pictures.

QUESTION: Can't you take a guess, Bill? Will it be too bright to look at, for instance? Will they have to use sunglasses?

SCHNEIDER: If you noticed our orbit work there, we do have some specific tasks to look at the washout when you are in the direct -- with the sun right over your shoulder --

and also to look at what the effects of the sunlight might be at the edges of the moon, and also to look at it from the back as we come around.

So one of the major things that we wish to accomplish on this mission is to answer just your question.

We do have the Lunar Orbiter pictures, and that is the best knowledge that we have right now.

PHILLIPS: One of the points I would like to stress which didn't come out when Bill talked is the importance of our planned work in lunar orbit in this mission to our navigation. There has been much talk about the mass concentrations near the lunar surface -- in other words, large masses concentrated near the surface and the large craters -- and much discussion of the effect of these large mass concentrations on navigation accuracy, and in particular the ability to predict accurately versus time your exact position and velocity.

The ability to do that, of course, is more important in a landing mission, because the accuracy with which you know your position at the time the lunar module starts its descent plays a great part in the accuracy of its landing. And we are very concerned-- Among the variables, we are most concerned about knowing the altitude above the surface at the time we start the descent. And we are very concerned also in the later mission, landing mission, with the navigation accuracy of the takeoff of the lunar module, its rendezvous with the command service module, which is obviously a life-critical function.

And in this connection we are most concerned among the variables also with the knowledge with which we know the altitude and the altitude rates.

Now, we expect with manned space flight navigation tracking accuracy and computation system to be able to measure the altitude to the order of five or so thousand feet. We want to be able to determine that more accurately. And one of the maneuvers that we will be accomplishing repeatedly in this C-prime mission is lunar landmark tracking using the on-board sextant and the guidance and navigation equipment.

Now, by tracking a point on the surface over an orbit -- in other words, while it's in view -- the rates of

change of the angle can be computed such as to determine we think quite accurately the altitude of the orbit.

We also will be making many measurements during these ten orbits to evaluate how accurately we can determine the local velocity and velocity change situations, all of these being important.

Now, we expect by the exercise that we will be carrying out on this mission to refine substantially the techniques that will then be available to us for later missions, and we will be doing so on a mission where we have quite a margin of propulsive capability, margin of time if we need to use it, to be able to make these kinds of measurements.

On later missions, like the F mission or the lunar landing mission, we'll need to know these navigation parameters very accurately, because they will be life-critical activities at that time. They are not life-critical activities on this mission.

But I think most of us are convinced that we are going to be able to refine our navigation techniques in very important ways that will give us a great deal more confidence and probably a great deal more certainty of carrying out a successful mission when we go out there with the full spacecraft and therefore have to be able to do these things for real.

QUESTION: Bill or General Phillips, no reference was made to the possibility of a strong solar flare being one reason for aborting the mission. Is that because you have confidence in the thick shell of the spacecraft being able to withstand even strong solar event?

SCHNEIDER: We will have our solar event system up. I don't think that we anticipate anything that would be big enough to abort. However, it is always a possibility that it would be an abort cue.

QUESTION: Well, what level of threatened radiation would be involved?

SCHNEIDER: I'm afraid I don't know right now. I can get you the number. I don't think we have a rule on it

right now. I think the spacecraft is adequate, but I will have to check that for you.

QUESTION: Will one of you gentlemen discuss a little bit more the photographing of the easternmost Apollo zone? Does this indicate, first of all, that this is the most promising area for landing? And, number two, could you cite any specific areas they would photograph in this zone?

PHILLIPS: Well, we have selected five sites across the face, the earth side, of the moon as the Apollo landing sites. You will recall the Apollo landing zone is along the equator of the moon as you look at it from the earth plus or minus 5 degrees in latitude, and from the center of the front of the face as it stands out plus or minus 45 degrees.

These measurements were set up by the early requirements of free-return trajectories and communications and navigation requirements.

The five sites that we have picked are one that is very close to the eastern edge of this rectangle. It's very near 45 degrees. And that's the point over which we will fly on the seventh revolution in this C-prime mission. There is another about 15 degrees toward the center or to the west, another very near the center of the moon, and then there are two in the west, one a little above the equator, and one a little below.

As the year progresses, our velocity situation lets us get more readily to a little north of the lunar equator on the west side than the other half of the year when we can get more easily to the southern site on the west side.

Now, the photography that we will be carrying out on this mission includes photography on the back side, including landmark tracking. One of the purposes of this is to provide geodetic -- selenographic is the right word -- tie-in of the geographic points on the back side.

As you know, Orbiter got a great deal of photography and mapped in different scales the entire back side. But we don't have all of the data with which to accurately tie various points to a map.

Now, this photography will let us do a great deal more of that. The photography includes stereo pairs and a close-time correlation as we track various sites. We will be taking a number of oblique photographs as well.

As you know, in our experience or in the operations from Orbiter, we got a small number of oblique shots, but on this mission, with the judgment and selectivity of the crew, we'll be taking quite a number of shots that amount to the approach path or the oblique shots as you look forward or sideways or aft, and this will be I think an invaluable aid for training future crews in what to look for and what to expect.

In addition to that, we will be getting considerable photography of the approach path to the moon. I have always thought that that particular maneuver would be a fairly exciting one if you visualize that the moon is moving around the earth in this fashion (indicating), and you are coming at it in this fashion (indicating), and you are going to approach it with several thousand miles per hour of velocity difference, and you are aiming for a perilune of 60 nautical miles which you reach on the back side of the moon. I think that's going to be quite an exciting period in this mission.

And the crew on this flight will be taking photography of how the moon looks as you come on down this trajectory.

I think that it's pretty hard to put a price on the value of each of these elements of operational experience and on the return that we will be able to bring back in the way of photography to make the way easier for subsequent crews who are going to be concerned with doing a lot more things like getting a LM checked out and separating and going down with it, and so on.

ALIBRANDO: Okay. We are going to go to Houston now and come back here.

QUESTION FROM HOUSTON: General Phillips, you covered in some detail the SPS system and the AC bus system. At the end of Apollo 7 you mentioned that in addition to the AC bus failure there was one other anomaly that gave you some concern, and that was the battery charger. Can you go over that a bit?

PHILLIPS: The question is the battery charger experience, Apollo 7. I emphasized that that was one of the many things that was covered in great detail in our reviews of the last weeks and days. The ability to put energy into the batteries on the Apollo 7 mission was less than predicted. The charge rate in amperes was lower than the planned charge rates.

It was determined really before Apollo 7 landed, but then verified by the spacecraft itself, that the impedance of the total circuit involving the battery and charger in the spacecraft, was a fraction of an ohm higher -- I have forgotten the exact number -- than expected. This hadn't been properly taken account of, and it was a plain old Ohm's law matter in the end that determined what the charge rate was.

We subsequently have made the necessary adjustment to the charge rate such that we will have no difficulty in maintaining the batteries at a high charge level on the Apollo 8 mission.

QUESTION FROM HOUSTON: General, what is the approximate training time for a flight of this nature, crew training time, and approximately how does that compare to operation with the lunar module?

PHILLIPS: The question is what is the approximate crew training time for this mission as compared to the mission involving the lunar module. I think for the record I'll get an absolute number for you from Deke Slayton. As I recall, for this mission we set up approximately 200 hours of command service module simulator time as the training plan, and we are very close to having accomplished all of that planned training.

As I remember it, the increment to provide for lunar module is somewhere between 50 and 100 hours additional.

But let us get it from Deke and give it to you so you will have it accurately.

QUESTION FROM HOUSTON: How does that break down into work-week time?

PHILLIPS: I didn't understand the question.

QUESTION FROM HOUSTON: How does that 200 hours work out in terms of a work week?



PHILLIPS: Well, the Apollo crew has been working six days a week, and I think their number of duty hours per week has been running 65 or 70 hours. That's not unusual. I think it is to be expected. It is about the kind of training schedule that the crews through Gemini and our crews in the Apollo now have always followed.

I think that the number of-- You see, the command service module simulator time per week runs about 20 hours per week for the prime crew and about 20 hours per week for the backup crew, if I remember. We are running to five-hour schedules at the Cape in the last weeks. The crew trained from eight in the morning until one in the afternoon, the prime crew or the backup crew uses the simulators, and then from one until six in the afternoon the other crew uses the simulators. And they are on a six-day schedule.

QUESTION FROM HOUSTON: I would gather in part from that you are getting very close to the point where you are going to have to start training crews for missions past Apollo 10. Can you tell us what those crews will be?

PHILLIPS: Well, we have several crews who are in general training beyond Apollo 10. You know we have three CSM simulators, one at Houston and two at the Cape. We have two LM simulators, one at Houston and one at the Cape. And then there are a variety of other training devices -- the crew procedures simulator and several (Park) task trainers on which our crews train.

The crews beyond Apollo 9 -- and there are several -- are training for all of the elements that constitute a full lunar landing mission.

We are, as you say, very close to the time when specific mission training beyond Apollo 9 is going to have to be undertaken as a specific mission set of training.

So we will in the fairly near future be announcing the specific crew selection for Apollo 10.

QUESTION FROM HOUSTON: During Apollo 7 there was some problem with the biomedical harness that caused loss of data, and we were told at that time if a similar

thing happened during the mission to the lunar vicinity that the mission would be aborted and they'd be called back. And yet today you tell us that if you lose the high-gain antenna, in which case you could lose biomedical data, this would not be the basis for ending the mission.

And, number two, what fix have you gotten on the biomedical harness?

PHILLIPS: Let me say first of all that the difficulties with the biomedical harness were mainly involving wire breakage. The small leads from the signal conditioners that the crew wear around their belt up to the transducers that are taped to various parts of their upper anatomy were I think over-designed in terms of fire protection.

We redesigned the biomedical harness, among the many things that we redesigned, to reduce any possible flammability. And the insulation on the wire that we put in to that redesign and the net by which the connections were made I think turned out to be an over-design in reducing flammability and introduced wire stiffness types of problems. So that we had a couple of instances in Apollo 7 where these wires broke.

Now, the design of this system was established such that you can't get sufficient electrical energy into that biomedical harness to cause a fire problem. That's been verified and reverified many times. So there is no real difficulty in going back to really the Gemini type harness which is much more flexible. There is not a fire problem with it. And I think this redesign we went through was really much more over-cautious than we needed to be.

So we have fixed that wire breakage problem in that way.

The other thing was Don Eisele reporting one of the signal conditioners that he had at the belt was warm or was hot to his touch. Since that time we have done a number of tests, have concluded that the possibility of moisture on a resistor as one possible example could cause a little higher amount of energy to go into that signal conditioner but only to raise its temperature by 10 degrees, and that would raise it up to something like 110-or-so degrees, which would feel hot or warm to your touch.

We have reverified that you can't get enough energy into that system to cause a fire problem.

So we have changed the leads. We have reverified the basic safety of the design features in the harness and in the spacecraft system that supplies it.

Now, the biomedical data does come down on the FM portion of the unified S-band signal, and if the high-gain antenna is not working we would not expect to be able to receive and adequately decode that data.

I don't recall saying nor do I remember it being said that we would abort a mission if we didn't have biomedical data. We have given this very careful consideration in the previous days and are completely satisfied to conduct this mission with verbal communication with the crew to determine their state of being, if we have to fall back on that mode because we don't have biomedical data.

And, accordingly, we made the decision to carry it out that way in case we have difficulty with the high-gain antenna and therefore reception and recovery of the biomedical data.

With that summary, I guess Bill wants to say something.

SCHNEIDER: Yes. I recall what you are talking about, and that was a flight surgeon's recommended flight rule on a lunar landing mission. And I hasten to add we haven't written those rules yet.

QUESTION FROM HOUSTON: Earlier, General Phillips, I believe you said that this mission into the lunar vicinity would shorten the time for lunar landing by a measurable amount. Could you tell us what that measurable amount would be?

PHILLIPS: I think I have already told you I don't know how to define it in dollars, cents, days, weeks, or months.

Just to say again briefly, with the technical data we will obtain on this mission that has to do with the performance of many of our systems and maneuvers, with the navigation information we will get, we will be able to proceed

with much greater confidence and assurance with each of the missions ahead, where in an F or G mission, for example, we don't expect to have the margins of time and propellants to be able to do some of the evaluations and obtain some of the data that we can obtain here.

It may be partly intuitive or judgmental, but I am convinced that this mission will shorten up our series, and I suppose if I had to put a time on it I'd say by the order of three months.

QUESTION FROM CAPE KENNEDY: This is the Cape. We have some questions here. General Phillips, this is Sue Butler. Could you tell us, please, whether or not the astronauts in Apollo 7 monitored the entry monitoring system where the range calculation was not working? Did they monitor? And then when you got it back and examined it, just what was wrong with it and how did you fix it?

PHILLIPS: The entry monitor system on Apollo 7, the range-measuring feature of it, was not operating properly on the reentry on Apollo 7. It turned out in post-mission evaluation that the scroll portion of the entry monitoring system was working properly. We have had the 101 spacecraft at Downey under various system tests involving being in a power depth mode since we got it back, and at least as of yesterday we had not yet removed the entry monitor system box from the spacecraft to dig into it and find out in detail what that malfunction that we reported before we took off really was.

I expect we will find that it is an open of the type we theorized before we flew.

The scroll can be taken out of the EMS separately. It does look like at this time the scroll portion was working properly.

We have an entry monitor system in the 103 spacecraft which is in good condition. We think one of the reasons we had the trouble we did with the 101 EMS is because in the months preceding the flight there were quite a few modifications put into it, reworks, and with complex electronic equipment one can make problems with multiple reworks, and that is one of the reasons we try to avoid it.

The one in the 103 has not been reworked in this way. And, beside that, it has been checked out properly in all the checkouts, so we think we have got a good one.

But we are saying now for some time that we do not require mandatorily the entry monitor system for 103 mission. The primary mode of reentering is with the spacecraft guidance and navigation system. The first backup mode is with the entry monitor system. The third backup mode is optical sightings and the constant g reentry that Bill described. With these series of backup modes we are really not concerned on this C-prime mission whether the EMS works or not.

I don't want to say that too negatively. We expect it to work. We think that this one will. We are protected against a failure, however, in case such a failure occurs.

QUESTION FROM CAPE KENNEDY: Question for General Phillips or Bill Schneider. Two questions actually. One, I understand there is no skip reentry as you describe it, but the question is why are you choosing this route instead of what we understood to be a direct skip reentry?

The other question, you have mentioned several times the high-gain antenna, this being the first time. Do you think it will work or has testing shown you may have trouble with it?

PHILLIPS: Let me answer the second question first. We have had some difficulty with the electromechanical control portions of the high-gain antenna in our qualification testing at the vendor's facility. These difficulties did lead us a few months ago to introduce some design changes to overcome those qual failures.

Those design changes were not available to be put into the equipment that is now aboard the 103 spacecraft for this mission.

The high-gain antenna and all of its control equipment were installed at the Cape back in September as I recall. It was checked out fully in all of its control modes as well as its RF modes. It worked properly. And at that point the equipment was stowed, because, as you know, it takes off inside the skirt of the service module. So it was stowed. The next time we will see that equipment is after translunar

injection when the spacecraft separates, and this antenna can be checked out.

We expect this equipment to work because it has passed its checkout and was working properly at the time we stowed it after checkout.

Now, we are mindful of the possibility of failures, because we did find certain small but important design deficiencies during the latter part of the qualification testing which are being fixed in later models.

And all of this is one of the reasons why we have given considerable extra attention to the high-gain antenna and have been able to provide for an adequate and safe mission all the way through the mission even if it doesn't work.

The other question is why are we flying a constant  $g$  reentry? I answered it in part before -- namely, that that provides us a simple, effective, reliable third backup for the guidance and control reentry mode or the entry monitor system reentry mode.

You know, it is obvious as you proceed through a major development program which is developing equipment and operational techniques that you learn a lot. That is one of the reasons you do it, one of the reasons why we go through all of these progressive steps. I think one of the things that we have identified in the reasonably recent past is that we have got a considerable margin in our reentry system.

I won't give you an exact figure, but I think our heat shield is capable of reentering at probably up to or maybe even greater than 40,000 feet a second. This mission is programmed at 36,300 roughly. So there is a great deal of margin there.

The reentry  $g$ 's can go well above 4 without raising any reason for concern. The design limit as you know is 20.

I think in studying the entire operation and the reentry regime in particular over the last several months, our people have come to the conclusion that this constant  $g$  reentry which gets you down to sub-circular speeds fairly

rapidly so that you can't skip out is maybe the way we will go on all our missions.

The previous technique of skipping -- well, not skipping out but coming into atmosphere then going back out for a period of cooling -- really isn't required. So we are able in this mission to introduce what we on balance feel is a third backup mode to our total reentry system which doesn't bring with it any other problems or concerns, and in the whole picture it's probably a safer reentry system.

And it may well be that that will be what we will use on all of our deep space reentries.

QUESTION FROM CAPE KENNEDY: Question for General Phillips. How long is the crew subjected to that 4-g environment, and are they capable during this time period to manually control the reentry if necessary?

PHILLIPS: They are capable of manually controlling the reentry at any point during the entire reentry. The period at which they will be at 4 g's is of the order of one-and-a-half minutes.

QUESTION FROM CAPE KENNEDY: If you for some reason decide not to go in lunar orbit and you continue into free-return circumlunar flight, how close will you come to the moon? And another thing I wasn't quite clear on is how many of the five sites do you plan to photograph?

PHILLIPS: We plan to photograph one of the five Apollo landing sites. You remember the lighting for this mission will be correct for the easternmost of these sites, so we will photograph one.

I'm sorry I forgot the first half of your question. Would you repeat it?

QUESTION FROM CAPE KENNEDY: Yes. If you continue just on free-return circumlunar flight, how close can you come to the moon?

PHILLIPS: Sixty nautical miles is the plan for the nominal approach distance on a circumlunar type mission.

I point out that-- Well, that would be the approach distance or the closest we would come if, for example, the decision were made to not make the lunar orbit insertion burn as a last-minute decision, because that would be the point at which you would approach.

But I would point out that if we made the decision some hours or many hours earlier, the total set of circumstances might cause us to raise that perilune to some greater height which would be fairly easy for us to do. So that flexibility is one that might be exercised in real-time depending on total circumstances.

ALIBRANDO: Okay. We have been going for three hours. Does anybody here have another question?

QUESTION: One quick one. What is the inclination of their orbit around the moon?

SCHNEIDER: Twelve degrees.

ALIBRANDO: Okay. We have a quote from Frank Borman in training at the Cape. If you will bear with us, we will read that. He says:

"We have been training very hard for this flight, and we're happy that the performance of Apollo 7 and other considerations that led to this decision permit us to go."

Okay. So much for the press conference. The transcript will be available tomorrow morning in the newsroom. If you want it mailed to you, fill out an envelope. The photographs showing the Apollo 8 orbital planning are available in Les Gaver's office.

(Whereupon, at 1:10 p.m., the press conference was concluded.)

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