COLLINS (CONT'D) drogue. If problems arose with the probe or the drogue, you have time to troubleshoot with the ground. I was glad to get that probe and drogue out a day early.

ARMSTRONG It was something you know that hadn't previously been done quite this way. It just seemed that it would make us more comfortable, going back and forth to the LM, that if there was anything wrong, we'd have some chance to talk and think about it and give the ground some time to think about it. That didn't turn out to be necessary because it was perfect, but still I think all of us felt a lot more comfortable having spent some time going back and forth and checking the stowage and looking over everything. The repetition just took the pressure off the next day's IVT.

ALDRIN Working in the very relaxed environment of the constant wear garment, there were no problems. We didn't really need to be restrained. I used the restraints and all it seemed to do was pull my pants down. You did have to be a little concerned about floating away from what you were doing; however, it was no great problem to push yourself back down to where you wanted to be.

ARMSTRONG This enabled us to get a little ahead in stowage.

ALDRIN Concerning transfer items: We brought several books back — updates and a couple of procedures.

ARMSTRONG So, all in all, I guess it worked out well. We recommend it as a useful procedure.

6.38 EATING PERIODS

COLLINS They were well spaced and I thought adequate time was given to eating. Quality of the food will be discussed later.

6.39 WORKLOADS

ARMSTRONG The workload during the translunar coast is very light as it should be.

ALDRIN In comparison to the preflight workload, it gave us a couple of days to relax. I think it's important to store up the rest.

COLLINS I think so too.

6.40 REST PERIODS

ALDRIN We're all good sleepers. The first one was not as good as the second or third, but the first sleep period was still surprisingly restful as far as I'm concerned.

COLLINS I think particularly when you get into the later flights of extended EVA's and lunar activity, somehow the crew must place themselves in a frame of mind of looking on the separation of the LM as the beginning of the flight plan and to relax, get plenty of sleep, and conserve their energies in all the events leading up to that point. To arrive in lunar orbit tired can create problems and it's possible to do that if you don't approach it in the right frame of mind.

ARMSTRONG I think Mike's hit the nail on the head. We did precisely that. We got a lot of rest and got into lunar orbit eager to go to work and that's a particularly fortunate position to be in.

COLLINS This is something we've talked about before the flight and I don't know how you can get yourself in that frame of mind but I think it is a frame of mind. You have to get yourself convinced that there will be a nice relaxing couple of days going to the moon.

ALDRIN The first unusual thing that we saw I guess was 1 day out or something pretty close to the moon. It had a sizeable dimension to it, so we put the monocular on it.

COLLINS How'd we see this thing? Did we just look out the window and there it was?

ALDRIN Yes, and we weren't sure but what it might be the S-IVB. We called the ground and were told the S-IVB was 6000 miles away. We had a problem with the high gain about this time, didn't we?

COLLINS There was something. We felt a bump or maybe I just imagined it.

ARMSTRONG He was wondering whether the MESA had come off.

COLLINS I don't guess we felt anything.

ALDRIN Of course, we were seeing all sorts of little objects going by at the various dumps and then we happened to see this one brighter object going by. We couldn't think of anything else it could be other than the S-IVB. We looked at it through the monocular and it seemed to have a bit of an L shape to it.

ARMSTRONG Like an open suitcase.

ALDRIN We were in PTC at the time so each one of us had a chance to take a look at this and it certainly seemed to be within our vicinity and of a very sizeable dimension.

ARMSTRONG We should say that it was right at the limit of the resolution of the eye. It was very difficult to tell just what shape it was. And there was no way to tell the size without knowing the range or the range without knowing the size.

ALDRIN So then I got down in the LEB and started looking for it in the optics. We were grossly mislead because with the sextant off focus what we saw appeared to be a cylinder.

ARMSTRONG Or really two rings.

ALDRIN Yes.

ARMSTRONG Two rings. Two connected rings.

COLLINS No, it looked like a hollow cylinder to me. It didn't look like two connected rings. You could see this thing tumbling and, when it came around end-on, you could look right down in its guts. It was a hollow cylinder. But then you could change the focus on the sextant and it would be replaced by this open-book shape. It was really weird.

ALDRIN I guess there's not too much more to say about it other than it wasn't a cylinder.

COLLINS It was during the period when we thought it was a cylinder that we inquired about the S-IVB and we'd almost convinced ourselves that's what it had to be. But we don't have any more conclusions than that really. The fact that we didn't see it much past this one time period — we really don't have a conclusion as to what it might have been, how big it was, or how far away it was. It was something that wasn't part of the urine dump, we're pretty sure of that.

Skipping ahead a bit, when we jettisoned the LM, you know we fired an explosive charge and got rid of the docking rings and the LM went boom. Pieces came off the LM. It could have been some Mylar or something that had somehow come loose from the LM.

ALDRIN We thought it could have been a panel, but it didn't appear to have that shape at all.

COLLINS That's right, and for some reason, we thought it might have been a part of the high gain antenna. It might have been about the time we had high gain antenna problems. In the back of my mind, I have some reason to suspect that its origin was from the spacecraft.

ALDRIN The other observation that I made accumulated gradually. I don't know whether I saw it the first night, but I'm sure I saw it the second night. I was trying to go to sleep with all the lights out. I observed what I thought were little flashes inside the cabin, spaced a couple of minutes apart and I didn't think too much about it other than just note in my mind that they continued to be there. I couldn't explain why my eye would see these flashes. During transearth coast, we had more time and I devoted more opportunity to investigating what this could have been. It was at that point that I was able to observe on two different occasions that, instead of observing just one flash, I could see double flashes, at points separated by maybe a foot. At other times, I could see a line with no direction of motion and the only thing that comes to my mind is that this is some sort of penetration. At least that's my guess, without much to support it; some penetration of some object into the spacecraft that causes an emission as it enters the cabin itself. Sometimes it was one flash on entering. Possibly departing from an entirely different part of the cabin, outside the field of view. The double flashes appeared to have an entry and then impact on something such as the struts. For a while, I thought it might have been

ALDRIN (CONT'D) some static electricity because I was also able, in moving my hand up and down the sleep restraint, to generate very small sparks of static electricity. But there was a definite difference between the two as I observed it more and more. I tried to correlate this with the direction of the sun. When you put the window shades up there is still a small amount of leakage. You can generally tell within 20 or 30 degrees the direction of the sun. It seemed as though they were coming from that general direction; however, I really couldn't say if there was near enough evidence to support that these things were observable on the side of the spacecraft where the sun was. A little bit of evidence seemed to support this. I asked the others if they had seen any of these and, until about the last day, they hadn't.

ARMSTRONG Buzz, I'd seen some light, but I just always attributed this to sunlight, because the window covers leak a little bit of light no matter how tightly secured. The only time I observed it was the last night when we really looked for it. I spent probably an hour carefully watching the inside of the spacecraft and I probably made 50 significant observations in this period.

ALDRIN Sometimes a minute or two would go by and then you'd see the two within the space of 10 seconds. On an average, I'd say just as a guess it was maybe something like one a minute. Certainly more than enough to convince you that it wasn't an optical illusion. It did give you a rather funny feeling to contemplate that something was zapping through the cabin. There wasn't anything you could do about it.

ARMSTRONG It could be something like Buzz suggested. Mainly a neutron or some kind of an atomic particle that would be in the visible spectrum.

7.0 LOI THROUGH LUNAR MODULE ACTIVATION

7.1 PREPARATION FOR LOI

ARMSTRONG With respect to preparation for LOI, our flight plan was written in such a way that it depended on doing midcourse 4 and option 1 P52 to get the landing site REFSMMAT into the computer and then an option 3 REFSMMAT P52.

ALDRIN Was that before midcourse 4 was performed?

COLLINS Yes, midcourse 4 was with the landing site REFSMMAT.

ARMSTRONG Then we did our simulation of LOI where we checked the gimbal motors and a 360° pitch maneuver to look at the Moon, followed by preparation for LOI. The midcourse 4 was cancelled. We did not do the option 1 P52 that established our new REFSMMAT. ... set up the computer for the LOI. When we got around to the P52 in the flight plan, which occurred at 73 hours, we did option 3. We recognized that we had never done a new P52 to an option 1. We are not sure that we could at that point in time.

COLLINS Did they have an uplink?

ARMSTRONG I'm not sure they had uplinked the necessary data into the computer. In any case, we recognized that we were not operating the way the flight plan had intended, due to this cancellation of midcourse 4; therefore, we got that information from the ground. We did a P52 option 1, then

ARMSTRONG (CONT'D) a P52 option 3, and our simulation of LOI where we brought the gimbal motors on and checked that everything was really copasetic. During this process we got behind the timeline because we did things differently than we had intended in the flight plan. Consequently, we cancelled the 360° pitch maneuver to photograph the Moon. We did not feel very bad about that since shortly before, when we went into the Moon shadow, we did look at it extensively through the windows and took a lot of pictures with the high-speed black and white film. I think we accomplished what we wanted to do in looking at the Moon from a relatively close range. We agreed to cancel the 360° pitch maneuver. We were then slightly ahead of the timeline in preparation for LOI. We spent a little more time discussing that among ourselves than we had planned, since it was different than our simulations.

ALDRIN There was something else. Was it just the two different alignments that got us a little bit behind?

COLLINS I think it was not having a REFSMMAT.

ARMSTRONG There was something else. I do not recall right now what it might have been. We did that secondary loop check, and a secondary radiator flow check.

COLLINS We could not see the stars. Was there a star check at a certain time? We were sitting around on one foot and

COLLINS (CONT'D) then the other waiting for something. There was a time in the pad when the star check was only valid after 11 past the hour.

ALDRIN That appears at some time. I don't see that written on this particular set up.

ARMSTRONG I might mention on the sextant star checks that, on most occasions, we manually drove the optics CDU's to the ground-computed values for the star and checked the attitude in that manner. That always worked for us. We were always able to see the star in the sextant field of view by manually guiding the optics rather than using the computer to designate the optics.

7.3 SPS BURN FOR LOI-1

ARMSTRONG Now we will go up to LOI. LOI was on time, and the residuals were very low. Again we saw a large value of DELTA V_C's — 6.8. Buzz will now comment on the PUGS.

ALDRIN We had been briefed on the experiences that Apollo 10 had had with the operation of the PUGS oxidizer blow valve, whereby they had responded to the initial decrease that the system gave them by placing the switch to DECREASE. Subsequently, it went to INCREASE. They followed it but were never able to catch up with it. It was suggested to us that the best procedure was to monitor this in the first 25 seconds, again expect it to be in DECREASE, and

ALDRIN (CONT'D) then expect that maybe even by going to FULL INCREASE you could not keep up with the system. With this in mind, I watched it throughout the burn. As soon as it started toward the -100, when it was around -120, I was convinced that it was in the upward swing toward INCREASE. I threw it to FULL INCREASE well before the normal ground rules required, and the valve went to MAX. Despite the fact that it was in INCREASE, the needle eventually went into the INCREASE position. I don't think we got over a 100. At the end of the burn we were three- or four-tenths behind.

ALDRIN Even by leading it as much as I did, I still ended up being a little bit behind. That was pretty small compared to what it could have been.

ARMSTRONG How about the burn itself, Mike?

COLLINS It was just about nominal.

ARMSTRONG Buzz, give the pad value for burn time.

ALDRIN 6 02.

ARMSTRONG Burn time was about 5 57. So it was 5 seconds ...

ALDRIN Yes. Fairly early in the burn, we could tell that.

COLLINS I remember, you were predicting that.

ALDRIN Three or 4 seconds early is what we predicted.

COLLINS Start transient was very small, and steering was extremely quiet and accurate. The chamber pressure, which we had

COLLINS (CONT'D) noticed to be a little bit low in the first SPS burn, climbed slowly and actually ended up slightly over 100. I put some specific comments on the voice tape. I thought it was a nominal burn.

7.5 ORBIT PARAMETERS

ARMSTRONG In postburn NOUN 34, we had a 60.9-mile perigee and a 169.9-mile apogee.

7.6 BLOCK DATA UPDATES

ALDRIN The LOS that we used, in addition to star checks, to tell us if we were in the right position relative to the Moon and the Earth was like the horizon check and is an additional cross check. These calculations turned out to be within a second of the ground-predicted time. When the ground said we were going to lose signal at 75 41 23, it was a second later that signal strength dropped down. It was very comforting.

ALDRIN We could see the horizon coming up a good bit before. I guess it was the one for TEI that was a little confusing as to which way we were pointed.

ARMSTRONG You were the only one confused.

7.8 ADEQUACY OF CONTACT WITH GROUND OPERATIONAL SUPPORT FACILITIES FOR LOI

ALDRIN Before the burn, I had noticed a difference in the A and B N_2's. I didn't record which one was higher. They were well within what we consider nominal; it stuck in my mind that there was a difference. It wasn't too surprising when the ground called us after the burn and said that they had observed tank B nitrogen had dropped down somewhat during the time of the burn. I think it dropped to 1900.

ARMSTRONG The values I have are B — 1950 psi and A — 2250 psi postburn. The helium was 1500 psi. Those came up a little bit after the temperature stabilized.

ALDRIN We'll talk a little more about that. Evidently there was not any particular leak. It might have been a thermal condition that one tank had been exposed to.

ARMSTRONG The flow through that particular solenoid valve could have been greater than emphasized.

ALDRIN We started that one on B and then went to A. I don't know if that would be any explanation.

ARMSTRONG I can't think offhand why that would affect it. The only thing I think about is the size of the orifice through which the gas is passing or the chamber size that, somehow, it was feeding ...

COLLINS I don't think we were ever concerned that we had a problem on the B side.

ARMSTRONG No.

COLLINS We were glad the ground was looking at it. It seemed to be all right to us.

7.10 ACQUISITION OF MSFN

ARMSTRONG In the post-LOI, we had a MSFN contact on time and did a P52 option 3 and 2 drift check. Those numbers were reported.

7.15 SPS BURN FOR LOI-2

ARMSTRONG LOI-2 was a bank A only burn. I assume this was to conserve nitrogen pressure in the B cell. This was a 17-second burn. Residuals were reasonable — 3.3, 0, and 0.1. The DELTA-V_C again was 5.2.

7.17 ORBIT PARAMETERS FOR LOI-2

ARMSTRONG Postburn NOUN 44 was 54.4 by 66.1.

COLLINS Did you want to talk about that orbit being targeted 55 by 65 rather than 67?

ARMSTRONG Yes, I think we made it clear on a number of occasions preflight that we were not in agreement with the change, just prior to flight, to the 55 by 65 orbit. We did not disagree with the intent of what they were trying to achieve; it's just that this did not have the benefit of

ARMSTRONG (CONT'D) its effect on a number of other areas of the flight plan. I still feel as though that was somewhat of a mistake. There were some other sides to the discussion that had not been fully reviewed by all parties.

SPEAKER What about items between the two maneuvers?

ALDRIN One item that came up was the request to look at the crater Aristarchus to see if we could see any glow or evidence of some observations that had been made by people on the ground. That does bring to mind that as we were coming in on LOI and I could see the edge of the Moon coming back into the daylight, it appeared to me that at one point (which I can't identify) there was one particular area along the horizon that was lit up. I doubt that it was anywhere near Aristarchus. There appeared to be one region that was a little unusual in its lighting. Maybe our films will catch that. We'll just have to try to identify that one when we see the pictures. I don't think that there is any particular connection, but I thought I'd mention it because it did strike me as a little unusual.

ARMSTRONG As long as we're talking about Aristarchus, I'd agree with Buzz's observation that the brightest part of the area that was somewhat illuminated might agree with the zero phase point of earthshine. This would mean that

ARMSTRONG (CONT'D): you're getting a lot of local reflection from earthshine. That certainly —

ALDRIN: You talking about once when we were in lunar orbit?

ARMSTRONG: Yes. I would certainly agree, particularly with the highly illuminated parts of the inside of the crater wall. I think it was also true that the area around Aristarchus, that is in the plains, was also more illuminated.

ALDRIN: It wasn't just the crater, it was the whole general area.

ARMSTRONG: It's not necessarily obvious that this also would happen to agree with the zero phase point of earthshine.

COLLINS: It could. We had nothing to compare it with.

ALDRIN: This was not in sunlight; it was in earthshine. That wouldn't have been zero ...

ARMSTRONG: Offhand, it doesn't agree with anything I can think of, and it seemed to extend for quite a distance around that area. Although I called that a fluorescence, it's probably not a very good term. It certainly did not have any colors that I could associate it with. There was just a higher local illumination level over the surface at that point.

ALDRIN: It was a brighter area than anything else we could see in either direction. I don't know if you could compare that

ALDRIN (CONT'D) with any of the brighter areas we saw in the sunlit portions — say on the back side; it didn't look like it was the same thing at all. Not having anything to compare it with in the way of earthshine illumination, we really couldn't tell much.

ARMSTRONG We could say the effect was there, and it was a very pronounced effect. It's a more obvious effect than looking at the Earth's zodiacal light. It's a more pronounced effect than zodiacal light which is also observed easily with the eye. Our post-LOI-2 P52 option 3 was a good one with an extremely low torquing angle (torqued at 81.05). After this, we prepared the tunnel for LM ingress.

ALDRIN Let's go back to the first time we went into darkness on the front side, in higher orbit before LOI-2. This was before we got to the region of the landing site. It wasn't illuminated at that point. I guess it's a question of your eyes being light-adapted to the lighter things that you are looking at that are in sunlight. The contrast when going into the terminator was very vivid. There was just nothing to be seen, yet you would wait a short while and then you'd pick up earthshine, and you could see quite well. As soon as the sunlit portion of the Moon disappeared from your eyes, you could get dark-adapted. Then we could start looking at things like

ALDRIN (CONT'D) Aristarchus. There was as much earthshine on the dark side of the terminator as there was later on, but your eyes could just not adapt to it, and it was just pitch black. After a short while you would be able to pick up fairly reasonable lighting coming from the Earth. I don't know what you would relate that to, or if you'd say that's at all adequate for any landing operations. I doubt that. It certainly did enable you to make observations.

ARMSTRONG I think that adequately states it.

ALDRIN We didn't do an extensive amount of observing in earthshine.

ARMSTRONG I thought it was about 5 to 10 minutes past the terminator before I was really observing things in earthshine very well.

ALDRIN I think earthshine is four or five times as bright as moonshine on the Earth.

ARMSTRONG I don't remember making the comparison. It was done on previous flights. Some of the people on previous flights thought it might be conceivable to make landings into earthshine. I don't guess I would be willing to go that far yet. It looked like the amount of detail that you could pick up, at least from orbital altitude, wasn't consistent with what you really need in order to do a descent.

ALDRIN You might do things like telescope tracking or even sextant tracking. ... characteristic features in the sextant, though we didn't try to do that.

ARMSTRONG It's difficult to pick out things in earthshine, unless it's a very pronounced feature like Copernicus, Kepler, or some of the bigger craters. You could see those way out ahead and track them continually. For smaller features that are not well identified with large features close by, I don't think you would be able to pick them up. We are ready for the second hatch removal now.

7.21 REMOVAL AND STOWAGE OF HATCH FOR IVT TO LM

COLLINS We stored the hatch in the conventional place, that is, in the hatch stowage bag underneath the left-hand couch. That was an easy and convenient place to stow it since they enlarged that bag and it fit very well. It was out of the way.

7.24 REMOVAL OF PROBE AND DROGUE

COLLINS We stowed the probe, as one of the previous flights suggested, under the right-hand couch with the nose of the probe in the plus-Y direction. It was strapped underneath the foot of the right-hand couch with two straps which were specifically designed to stow it. We just stuffed the drogue in between the LEB and the probe and held it

COLLINS (CONT'D) in place with a couple of general-purpose straps. It seemed to work well.

ARMSTRONG I was thinking ahead about our overall LM stowage which was different from our preflight plan with respect to leaving the probe and drogue stowed in the command module overnight.

ALDRIN After LOI-2.

ARMSTRONG Subsequent to this time.

ALDRIN It seemed that all the pluses were in favor of doing that.

ARMSTRONG I agree; I really did not think it was a big thing. We did it to try and save time at the start of the DOI day. We had it removed and it was stowed. That meant that on one night, we had to arrange a sleep configuration with the probe and the drogue stowed in the command module.

SPEAKER Who slept with this?

ALDRIN I did. It was a little cramped under the right seat with the probe and drogue, but I was able to sneak in underneath it. I think I made one exit over the hatch end of the seat. I guess the only thing that leaves you a little bit open to having the probe and the drogue in the command module is if you've gotten separated from the LM.

7.29 TRANSFER OF EQUIPMENT

ALDRIN In our activation checklist, we have a CSM to LM transfer list. We reviewed this, added a few things, and put some

ALDRIN (CONT'D) notes on it. I think it would behoove follow-on crews to pay close attention to this type of list, especially if they use this list to record anything that is brought back into the command module from the LM.

We brought the purse back in with us. The transfer storage assembly, along with one transfer bag, was used to keep track of everything that was going to be transferred to the LM the next day. We elected to take a few snacks in with us and also added tissues to the transfer list. In thinking about it, I don't believe we had any tissues in the LM.

ARMSTRONG There were, but we couldn't recall where they were.

ALDRIN I still don't recall where they were. We had a couple of towels but we certainly needed the tissues. We found that out the first day we went in translunar; when we pulled the window shades down, the windows were covered with moisture. In order to get any pictures and to test the cameras, we had to bring in some tissues and wipe the windows off. We found considerable use for the two packs of tissues that we took in. I think that is something that ought to be added to the LM stowage.

ARMSTRONG It is probably worth mentioning that, due to various attitude constraints, sun positions, and so forth, you frequently find yourself putting the LM window blinds up

ARMSTRONG (CONT'D) and down in lunar orbit. When you put them up, you are going to start to collect moisture on those windows in some attitudes. Invariably, when you take the window shades down, you have partially degraded windows.

ALDRIN It took a long time. You couldn't just wipe it off once; it came right back because the glass had cooled so much.

ARMSTRONG It would clear if it was left exposed to the sunlight for a significant period of time, but we didn't always have that much time before we had to be tracking or looking at the ground or doing something else. Having the tissues or towels there to dry those windows off so that we could use them as windows was important.

ALDRIN Another item that we added to the transfer list, and we asked for approval from the ground for this, was the monocular. We felt we could use it more in the LM than Mike could in the command module so we took that in with us. We did use it on the surface, looking at and observing certain rocks before and after the EVA. I certainly will recommend that crews have something like that onboard the LM, in the way of a magnifying device.

ARMSTRONG It is useful also before EVA to help plan your EVA routes and objects of interest.

ALDRIN I might mention that when we went in there the first day, I did go over the circuit-breaker checklist that we were

ALDRIN (CONT'D) going to do on LOI day and I also went over the complete switch checklist. In essence, we got ourselves 1 day ahead. On LOI day, I went over the circuit breakers but did not go through the complete switch list again. That gave us a little more time to go through the rather brief COMM procedures that we had. I might mention here that the systems test meter in the command module showed that the LM power position was always within limits. It did oscillate rather rapidly between about 0.3 or 0.4 and about 2.2 volts; generally around 1.2. The on and off cycling of the LM loads was much more rapid than I had anticipated.

ARMSTRONG Every few seconds, the voltage level of the LM bus would change significantly.

7.31 POWER TRANSFER TO LM

ALDRIN I have logged the times of transfer to LM power, 83 hours even, and transfer back to CSM power, 83:38. The intervening time was spent checking out the COMM. All of this was done on low voltage tap. We checked the OPS pressures both on the first and second days and they were well up there - 5750 and 5800. The REPRESS valve certainly does make a loud bang when you move it to CLOSE. There doesn't seem to be any way to avoid that, especially when you go to CLOSE; it seems you are relieving some pressure.

ALDRIN (CONT'D) When you go to REPRESS, it is possible that you could avoid it by being very deliberate when you open it. I wasn't able to do it any of the times that I activated it. The COMM seemed to be very loud and clear. I guess that's about it for the LOI day activation.

ARMSTRONG Just about this same time we had a P22 - our first P22. Comment on that, Mike.

7.33 LANDMARK TRACKING

COLLINS It went normal. I have on my map the location of the crater on which I marked. I'll give that to the appropriate people. All procedures, the update, the map, the acquisition, everything was nominal.

ALDRIN I'm not sure whether it was this pass or the one before that you were back in the command module and we had a good view of the landing site coming up. I'm sure it must have been because we were too busy to be gazing out the window on DOI day. I'd recommend that both LM crew members be in the LM on LOI day. Even though you thought you had a good view, I was convinced that I had a much better one than you did.

ARMSTRONG You probably did.

ALDRIN ... straight out the window of the approach. I think both crew members probably ought to be in the LM during that time.

7.37 CONSUMABLES - ACCOUNTABLE

COLLINS Because of transposition and docking and P23, we started off behind on RCS and we stayed slightly behind on RCS. The other consumables, oxygen and hydrogen, were within limits. What about LM consumables?

ALDRIN I guess we went to bed according to the flight plan. How many hours did we have scheduled?

ARMSTRONG We had a 9-hour rest period scheduled starting at 85 hours.

ALDRIN I think the reason we were able to be in position to take advantage of the rest period at the beginning of it was because we had already gotten used to the LM operation.

ARMSTRONG I guess we knew all along that that could be the problem on our timeline, just as it could have been on 10. Anytime you get hung up in that DOI day on LM systems, you're not going to make it. We had that same strong inclination to try to be ahead and try to understand the LM as best we could before that time period.

8.0 LUNAR MODULE CHECKOUT THROUGH SEPARATION

8.1 COMMAND MODULE

8.1.1 CSM power transfer

COLLINS I recall that went without incident. Prior to this time, the CSM had been providing power to the LM heaters, and you could watch the load cycle on the service meter as the heaters cut in and out. They were always within limits. Eleven amps is supposed to be the maximum and I don't think we ever went over two-thirds of that.

ALDRIN I think it's worth while to point out that we didn't jump ahead of the timeline by getting up early. I think we felt confident that the time we had was sufficient.

ARMSTRONG We had 2 hours before we went in from wakeup. I think it probably worth mentioning that, none of us got as good a night sleep that night as we had the previous night. I'm sure it was just that the pressure was beginning to build at this point. We were coming up on DOI day. We got 5 to 6 hours sleep that night. I guess I should have expected that.

8.1.2 Updates

COLLINS They updated us with the fact that Al was 500 feet above the landing site. That didn't seem to turn anybody on

COLLINS (CONT'D) because the LM charts aren't that accurate.

8.1.3 IMU realign

COLLINS We did the IMU realign, and it worked okay.

8.1.5 Assist LM VHF A and B checks

COLLINS I assisted the LM VHF checks, and they worked fine.

8.1.6 Tunnel closeout; probe, drogue, and hatch

COLLINS Tunnel closeout went normally. The probe, drogue, and hatch worked flawlessly. At this time, I was on this solo book, and the solo book worked well. I went through it and checked things off item by item. The undocking went normal. You may want to say some things about that undocking and stationkeeping in regard to who was going to thrust, how it worked out, and what it did to our state vectors.

ALDRIN We do want to go back and review some LM activities.

ARMSTRONG Let's go back to the tunnel closeout. As I remember, you were clicking along in good shape there, but we were well ahead over in the LM. We were, in fact, waiting on CMP to get this whole long series of things done. That was completed by clearing the tunnel and getting that ready for us to go. This is a time period when the LM and command module activities are interrelated

ARMSTRONG (CONT'D) and dependent on each other. You have to do things in particular order and be careful that you don't get out of sequence here. That was the first place where we had to sit still and wait.

COLLINS It did go according to my schedule; it went right along like it should have. There isn't much you can do to hurry that probe and drogue. All that I did in that tunnel I did very slowly and deliberately as per the checklist.

8.1.7 Maneuvering for landmark tracking

ARMSTRONG The next thing we did was maneuver to the tracking attitude which you had to do after getting the tunnel all set up to do the P22.

COLLINS The hooker was I couldn't do that until the tunnel had vented down to a certain pressure level. There is a constraint on 2-jet roll, 4-jet roll, and no-jet roll, depending on the condition of the tunnel. That may have been when you were just sitting there waiting. I had you inhibit roll command until the LM/CM DELTA-P was rated at 3.5. Then I had 2-jet roll started and I was going to start maneuvering to the track attitude. All that timeline went exactly according to the flight plan. If you were ahead, then that was the point at which you

COLLINS (CONT'D) had to stop. We did P22 on crater 130 this time, and it was with half-jet authority because you'd unstowed your radar antenna. I had to deactivate two thrusters. P22 went just fine.

ARMSTRONG Then you maneuvered to the AGS calibration attitude.

COLLINS The AGS calibrate attitude held steady. As far as I know you were leisurely able to get a good AGS cal.

8.1.13 Undocking

ARMSTRONG Undocking was one of the things that had to be done very carefully in order to avoid getting some muddled DELTA-V in the state vector from which we could never recover. The procedure that we used was one that was agreed upon within the last week or two before flight. It involved the LM getting up both P47 and the AGS during the undocking time and zeroing the DELTA-V's of the undocking. P47 was one that we chose to zero. As I remember, there was a little residual left in the AGS. Do you remember, Buzz?

ALDRIN Yes.

ARMSTRONG We went P47 to zero, and we still had a little left in the AGS. I can't remember whether it was 0.1 or 0.2.

ALDRIN It was 0.3 or 0.4. It jumped - this was in 470. It just appeared to us that since we had P47 going it was probably the more accurate of the two.

ARMSTRONG After separating for a distance of 30 to 40 feet — then taking the DELTA-V out in P47 — we asked Mike to choose his own separation distance for watching the gear. He then stopped his relative motion with respect to ours; and the intent was, at that point, both vehicles would have exactly the same state vector that they had prior to undocking.

COLLINS Any error we had in there might well have been the reason why you might have been long.

ARMSTRONG Possibly, it may have contributed to that.

COLLINS I don't know how much error we had in there. I did have to fire lateral thrusters several times and pitch thrusters once or twice. As near as I can tell, those things should have just about compensated for each other.

ARMSTRONG It was our intention to try and keep the command module from firing any thrusters once he had killed the relative rate. We didn't quite accomplish that.

COLLINS I didn't have to fire any toward you or away from you, but I had slow drift rates back and forth across you and up and down while you were doing your turnaround maneuver. I had to kill those rates. I don't know how they developed.

ARMSTRONG The resultant stationkeeping was one that was very good. The vehicles were pretty much glued together, 50 to 70 feet apart. How about the inspection?

COLLINS Inspection consisted of two things, a gear check and a second just looking for any obviously damaged parts or bits of hanging debris. The LM looked normal to me. I had to confirm three of the gears by actually checking the downlocks. I never could get into a position to check the downlock on the fourth gear. I think it was in position initially for downlock inspection but I missed it due to camera activity. Then it rotated around, and I never really could check the fourth downlock. I was relatively confident in saying all four of them were down and locked just by the angle which the gear itself made. All four gears were at the same angle.

I took considerable 70-mm as well as 16-mm pictures during this time. If I had spent more time looking out

COLLINS (CONT'D) the window and less time fiddling with the cameras, I probably would have had to fire the lateral thrusters and vertical thrusters a little bit less. I called P20 after the separation burn.

The SEP burn was within 8 seconds of the flight plan time. I called P20 in that little football we were in, but it was not very accurate. The flight state vector ... make considerable inaccuracy in P20, so the sextant was not able to track the LM.

I had been on the solo flight plan book now ever since a GET of 94 hours. This solo book concept, where I had all the information I needed in one book, worked very well. I have no suggestions for any modifications to this book. I used the flight plan as a basis for it and then I inserted more detailed pages during the intervals when the timeline was busy. My original intent in using that approach was that it would be less work for the people who had to make up the book if they could start with something that already existed, like the flight plan.

COLLINS (CONT'D) At any time, I could see what was going on inside the LM if I had an inclination to do so. I'm not sure it turned out to be any less work. I never was too concerned about what was going on inside the LM, but it did have one great advantage which sort of accidentally fell out. The detailed procedures were done by the McDonald Douglas people, and the flight plan was done by the flight plan people; and in case after case, the two did not agree. Having them sandwiched in belly to belly immediately pointed out areas where they did not agree. The two groups would then get together and find out why they did not agree. It was a good mechanism for making sure that all counties were heard from. The command module solo activities were exactly in keeping with the flight plans. For that reason, I recommend this particular format.

8.1.21 Rendezvous radar and optics checks

COLLINS About the only optics checks I got prior to DOI was the fact that I could see the LM through the optics. P20 was not that accurate.

8.1.22 Fuel cell puring

COLLINS Fuel cell purging was nominal.

8.1.23 Update pads

COLLINS Update pads were good.

8.1.24 COAS calibration

COLLINS I did not calibrate the COAS.

8.1.25 COAS tracking

COLLINS I did not track with the COAS. After DOI, I did P20 tracking of the LM. I updated the state vector by using both VHF ranging marks and sextant marks. This is something that was not part of the original flight plan. There was no requirement initially for the command module to track the LM between DOI and PDI. It was something that I added and I'm glad I did, because it allowed me to see that the system was working. We had no scheduled checks on it to see that the mark data were incorporated and just generally to prepare for the next day's activities when I would be marking on the LM for real.

8.1.26 Workload, timeline, and flight plans

COLLINS This was a fairly busy time in the command module. These procedures were well designed, and I was able to stick with the flight plan.

I did get some accepted updates from the sextant marks. They were: 6.1 ft/sec, 7.1 ft/sec, and the third one 3.7 ft/sec. From there on, they were all down below the threshold.

ALDRIN I've given you several thoughts on the various things I had to do — where I was going to put things, when we were going to get the LCG's out, when we were going to open them up, and that sort of thing. I think when the time came to do this we didn't have to do a lot of fumbling around. We knew just what to do. There's only one exception to that — our athletic supporters. I had no idea where they were. I thought they might have been in the same compartment with the SCS's and the LCG's. I didn't see them anywhere, and we couldn't see asking the ground where the heck they were. Finally we said to heck with it, and if they weren't there, why we'd get along without them. Low and behold, they were inside the LCG's when we opened them up.

ARMSTRONG I think I commented that is where they were stowed, but when we looked in the LCG's we sure couldn't see them anywhere.

COLLINS I thought those had been sealed up long ahead of time.

ARMSTRONG Yes, that's what I remembered, but we sure couldn't prove it to ourselves.

ALDRIN I don't think there was anything that got me hung up at all in getting a good meal. We knew that we would be going about 6 to 8 hours, at least; so we had a good size breakfast, took care of everything, got up about on schedule, suited up, and stowed things pretty well in the LM.

8.2 LUNAR MODULE

8.2.1 PGA donning and IVT

ALDRIN Mike had things well under control, and I'd been into the LM twice before, so the entry procedure went very rapidly. We were due to go in at 95:50.

ARMSTRONG We did no complete self-donning. We always used whoever else was available to help with zippers and check where-ever they could. We checked each other whenever time allowed.

8.2.2 Power transfer activation and checkout

ALDRIN I transferred to LM power at 95:54. We did enter the LM right on schedule. We didn't get ahead. I think we had built up enough confidence in the activation procedure by having done this many times in the SIM's. Gene Kranz wanted to run as many of the DOI and PDI SIM's as we could, starting right from activation, and I think it was a good thing that we did. Leaving the simulator run, we found that we had plenty of time to go out and get a cup of coffee or make a phone call and get back in again. Having gone over this many times, we had the confidence to go ahead and not try to jump ahead. I think that things worked out quite well. We were gradually, comfortably getting 15 to 20 minutes ahead.

I'd liked to have delayed going to the high-voltage taps and activation. Page 19 says to go ahead and do that and get the bus voltages below 27, but they weren't. I don't recall the exact time in the checkout when they did begin to approach 27. I think it was during the circuit breaker activation when we put everything on the line. It was about that time that the voltage

ALDRIN (CONT'D) started going down. Here is an example of how our time schedule went: caution and warning checkout was to start at 96:41, and at the latter part of that is a step called primary evaporator flow 1, open. I logged 96:05, as the time we opened that. At that point, we were 30 minutes ahead. In the circuit breaker activation, the only funny that I observed was in putting the LGC DSKY circuit breaker in. We had a program alarm 520 on the DSKY; 520 is radar erupt, not expected at this time, and I can't explain that. We reset it. We didn't have any radar on. We'll just have to see what the people say about that. I think that Neil came in just about on schedule. I was able to accomplish three or four headings that we were going to be doing together. I had to wait until he got in before doing the suit pan water separator check. He had to be hooked up at that time. It appeared as though it wouldn't be wise to get that one out of sequence. I did get the glycol pump check at 97:05. I recorded that Neil was in. By the time he came in, I was to the point where I was ready to go back in and put my suit on. That got me something in the vicinity of 15 to 20 minutes ahead. I knew we pretty well had it made at that point. We did the

ALDRIN (CONT'D) E-memory dump, and you did some work with the DSKY and the alignment checks.

ARMSTRONG The E-memory dump was repeated for some reason or other. I think we lost S-band.

ALDRIN I can't recall if it was an attitude problem, but we did do that again.

ARMSTRONG For some reason, we lost the high bit rate during this time period. The VHF checkout was good. Both VHF A and B between the two vehicles were good. The time and T_{EPHEM} initiations were without problem, and we did the docked IMU coarse align. The advantage of being slightly ahead showed itself in that MSFN was able to compute the torquing angles before we lost signal with them, before we went on the backside. They gave us the torquing angles, and we torqued the platform at 97:14, about an hour before we were scheduled to do the initial torquing. This gave us better drift checks, which was a help in analyzing the LM platform. We had never done that in the SIM's. Later on I was a little confused in my own mind as to what cages that might result in and whether we would have the subsequent torquings about an hour and

ARMSTRONG (CONT'D) a half later. At this time, I had nothing really further to do until Buzz returned with his suit on. When he came back, we only had to wait on Mike to get the tunnel closed up before we could continue with things like the pressure integrity checks and regulator checks.

ALDRIN It seemed to me we spent a good bit of time holding at just about that point.

ARMSTRONG We were a little ahead, and it turned out that there was very few things that we could do or wanted to do at that point.

8.2.5 ECS

ALDRIN The glycol pump sure made a lot of noise.

8.2.13 Ascent batteries

ALDRIN You kind of hate to bring the ascent batteries on the line. You've got a system going and then turn off all the descent batteries just to prove that the ascent batteries are working. You have no backup if you turned off all the batteries; at that point, everything would go dark. Maybe that wasn't the only way you could go about checking to see that the ascent batteries worked. But, that worked out all right.

8.2.15 ARS/PGA pressure

ALDRIN The pressure integrity check held with the suit loop decreasing maybe 0.1 or something like that. I think there is a little lag in there when you first close the regulators. The tolerance is 0.3. It wasn't anywhere near that. There wasn't any significant change going to the secondary canister. The regulator check is a fairly involved setup of valve switching. I'm sure all of these things are nice to do, but unless you have an extremely intimate knowledge of exactly what you're doing, you can run into some problem there. The fact that you're doing this one step right after another puts you in a non-nominal situation. I would much prefer that this sort of a check be done on the Earth side where you have COMM, because you're dumping the cabin pressure down and you're using a REPRESS valve. I think the ground would agree with that, too. If in other flights it could be worked into the earth-side pass, I think it would be beneficial.

ARMSTRONG I agree with that, although I think the pressure integrity check is relatively straightforward.

ARMSTRONG (CONT'D) But these two are coupled together. It's tied to the tracking and to the tunnel closeout.

8.2.16 AGS activation, self-test, calibration, and alignment

ALDRIN We had already had the platform up and it had been aligned to the command module's platform, so I went through the AGS initialization update. I knew that we didn't have a state vector, so there wasn't any point in putting the state vector in. I was smart enough at that point to recognize this and I knew that the state vector was coming up later. But I thought, "Well, there's nothing to stop me from aligning the AGS platform to the PGNS platform," so I did this and immediately looked at the AGS ball and it was way out in left field. It didn't agree to the PGNS ball at all, and it took me about 5 minutes or so to try and figure out why this was. I finally realized that the reason for it was that the PGNS didn't have a REFSMMAT, and its computer didn't know where its platform was. Even though the platform was in the right spot, it didn't have any reference system so it couldn't tell the AGS what its platform ought to be. The AGS platform, in terms of the command module, is in the forward plane. The PGNS didn't know this.

ALDRIN (CONT'D) It just came up with some garbage. Well, this caused a little bit of concern because we were quite anxious to have the AGS with us for the whole flight. We were beginning to wonder whether we would or not. Let's see, there was one funny thing that I don't think we've mentioned. It was pretty minor. One of the strokes on the DEDA was not illuminated. Each character is made up of all these different strokes. The one missing was in the middle character, and it would leave you in a position where you couldn't tell whether it was a three or a nine. I didn't realize at the time that there was any room for confusion. Later, in looking at some numbers, you could not really tell whether in fact that was a three or a nine.

ARMSTRONG Yes. You just need that one stoke to close it, and it becomes a nine.

COLLINS I got the bottom one.

ALDRIN With this particular one missing, there was some doubt as to exactly what you had.

ARMSTRONG That's true of any digit on any of those electrical switch displays.

COLLINS Remember, we had one of those in the EMS.

ARMSTRONG Yes, that's right. Fortunately, the simulators usually got some out and you got used to putting up with that. But, it's a problem that really could get to you sometime if you misinterpret that number.

ALDRIN We missed putting the AGS time in there. We missed by 15 centiseconds hitting it right on, which I thought was very close. We did even better than that when we updated at 120 hours.

8.2.17 S-band antenna

ALDRIN The S-band antenna seemed to work very well at this stage. It didn't make quite as much noise as I had anticipated.

ARMSTRONG However, it was noticeable.

8.2.18 ORDEAL

ARMSTRONG As we set up the ORDEAL, we got back to our favorite argument. That is, what is right to set in the ORDEAL - the AGS or the PGNS, when you're at nonzero yaw? I guess we believed that it was the AGS that was right.

ARMSTRONG (CONT'D) We set it in and as it turned out, it was right and the PGNS was wrong. By about 40 degrees or something like that.

ALDRIN The PGNS was wrong by 40 degrees.

ARMSTRONG That's an interesting one, because you can get either answer depending on who you ask; I still think that today. We at least proved to ourselves that the AGS was the correct one.

8.2.19 Deployment of landing gear

ARMSTRONG Landing gear went down very nicely. No problem with the landing gear and there was no question about that one.

ALDRIN We were expecting two distinct sounds, but really they weren't identical sounds. You could hear the PYRO's fire, and just a short time after, there was not as much sound as there was a vibration transmitted up that indicated something had locked down. Of course, we had no way of knowing how many of them had done that. However, when we did fire, we opened up logic power A when we fired them, and then we closed logic power A and fired again, and at this time we heard a click just like a relay going, but no PYRO's fired.

8.2.23 DPS gimbal drive and throttle test

ALDRIN Now, how about the gimbal trim.

ARMSTRONG We did not drive the gimbal. Some question arose while we waited for confirmation from the ground, but they had proper gimbal positions, and we did not have to drive.

8.2.24 RCS pressurization and checkout

ALDRIN I recall no problems there. The parker valves in the talkbacks gave us some rather funny responses. Gene's comments indicated that when you activate one of the quad pairs or main shutoff valve to a particular position, it didn't go to that new position until you released it. Through most of our training in the simulator, you'd move that valve as soon as you'd get it to the spring-loaded position of open and close, it would change, and it would stay changed when you would release it back to the center. If it didn't work that way, when you moved it, it didn't go to its new position until you released it. So we changed the simulator.

We found something even further than that. The ascent feed 1's were open, and the 2's were closed. All of

ALDRIN (CONT'D) them were barberpoled as we expected. After pressurization, the procedure was to go through and cycle each valve to its present position - where it should be. So, I went to the ascent feed 1's and went open, and nothing changed; it stayed barberpole. As soon as I went to number 2, the closed position which would put them barberpole, they both went direct. They went to the opposite position that you would not expect. When I released it, they went back to barberpole again. I think the same thing happened to the shutoff valves. When you'd move it to the closed position, where it should go barberpole, it would go gray. Then, as you released, it would go to its present position. You can't tell the position of the valve until you release it. As a matter of fact, it'll give you the opposite indication in some cases.

We had good helium pressure and read that out to MSFN. We went through the RCS checkout. We had one quad, upper right-hand one, that stuck two different times in the red indication.

When going through the cold fire, we were getting all different stories from the ground as to whether these

ALDRIN (CONT'D) talkbacks would go red. The final one that I got was, "No, the latest story is they won't go red on you." Well, they all went red. First four of them, then all of them went red. It's a very light-colored red, I might add. It didn't look much like the simulator. It really stands out much more than the simulator.

We got the numbers we ran on the DSKY when we went to the soft stops. For the most part, they agreed precisely. There were a couple of them that missed by one last digit, but we were told that that was not significant.

8.2.25 Rendezvous radar and self-test

ALDRIN Everything went just as expected. I've got the numbers written down here; they're all within limits.

8.2.26 DPS preparation and checkout

ARMSTRONG DPS preparation and checkout went as expected.

ALDRIN The AGS CAL attitude angles are written down in my log. Mike maneuvered to the angle, and we're steady as a rock for a good long time period; more than adequate time period to perform the check.

ARMSTRONG I'd always wondered if there was anything that you could do during the AGS CAL 5-minute period that would maybe give a little jolt, go back to the AGS, and give you an erroneous reading so you wouldn't pass. In any case, we just avoided that problem by not doing anything except the AGS CAL during the AGS CAL. We didn't pressurize the DPS, or put down the landing gear, or run the rendezvous radar or any of those things which might put a little oscillation into the spacecraft and trigger an accelerometer or something of that sort that might cause a problem. We just let it run all by itself.

ALDRIN This pressurization sounds like a big thing, but really it took about 2 minutes to do.

ARMSTRONG Yes.

ALDRIN And we went through the final circuit breaker verification. Cards worked quite well. We'd lose maybe a little bit of time by having to pass them back and forth. I don't think that's too significant.

8.2.28 Undocking

ARMSTRONG Undocking was very smooth. We had a very good visual. We could always tell where the command module was by

ARMSTRONG (CONT'D) looking out the window. We commented on our concern about the manner in which the undocking was controlled. I think there's still room for improvement on that procedure. One that was discussed before flight was: extend the probe, and then release the capture latches — essentially have no velocity between the vehicles. Then the command module really wouldn't move at all at the time we clear away and wouldn't compromise the state vector in any way. We thought that might be a very good way to do things but we just didn't feel that there was enough time before launch to look into the secondary effects you might get out of doing something like that, so we chose to go with the way undockings had been performed previously. That may be something future flights might want to look into with more care than we were able to.

ALDRIN Putting the helmet and gloves on and off didn't seem really to be much of a bother. We put them on for the integrity check, took them back off again, put them back on for undocking, and took them off. The little piece of Velcro on the feet port worked quite well, just slapping it down on the ascent-engine cover. I put my gloves over by the right-hand controller. You could put them in the helmet just as well.

ALDRIN (CONT'D) The verification of about 8 to 10 AGS addresses I was able to get done before undocking. There is a bad amount of data that the ground reads up to you in that time period — the DOI, PDI, PDI plus 12 pads, and various loads that are coming up. You have to devote one man just to copying all those things down. It seemed like it took forever to get them all done. Even after we got those, we still had some more coming up after DOI; the surface pad had to come up.

8.2.33 Formation flying

ARMSTRONG Formation flying was considerably less difficult than our simulation would lead us to believe. We were able to maintain position with respect to the other vehicle. It was less trouble than in simulations and used less fuel. At separation, we thought we had relative velocity nulled to less than 0.1 ft/sec in all axes. This was based on the size of the translational inputs required to maintain a constant position over past 10 or 15 minutes before separation.

ALDRIN We did add 20 degrees to our pitch attitude after undocking, so that we'd get better high gain during the yaw

ALDRIN (CONT'D) maneuver. That, I think, is peculiar with the particular landing site, but we were able to get high gain lockon. As a matter of fact, I could have gotten it before we made the pitch maneuver, but it didn't look like there was too much point in doing that.

As soon as we finished the pitch maneuver, we had high gain lockon and had it throughout the yaw maneuver. I was going to take some pictures with the 16-mm camera mounted on the bracket, but it looked like it was canted off to the side.

No comment at all on using the AGS for this versus the PGNS. We made a change from MAX deadband to MIN deadband. This to me is an open area.

ARMSTRONG We were in AGS, ATTITUDE HOLD, MIN deadband, and PULSE in the axis that we were maneuvering in. The separation attitude was not the attitude we had expected to be in as a result of some changes to the ephemeris at this point. In other words, Mike was separating on the local vertical, but that was not at the same inertial pitch angle that we expected to be at. It was off by about 10 degrees as I recall.

COLLINS No, SEP occurred within about 8 seconds of the planned time.

ARMSTRONG You did separate on the local vertical? The pitch attitude that we were at was about 10 degrees different.

COLLINS It was a 7-degree-different attitude. It was pitch 007 instead of pitch 014.

ARMSTRONG I was holding in the attitude that was on our timeline, and sure enough, it didn't look like you were in the right attitude. Some changes occurred after launch that we didn't properly appreciate. In any case, 285 is what we expected to be. That wasn't the right number. That was important, because it was the thing that made the COAS point at you and check lateral translations, comparing the formation flying during separation.

Immediately after this, we did the landing radar test, right after your separation. That went well, as I remember, everytime.

ALDRIN Yes, they were right on.

ARMSTRONG After that, we did our first alignment in the LM, fine align, P52, option 3. We did that on the flight plan

ARMSTRONG (CONT'D) stars, Acrux and Antares. The torquing angles were about 0.3 degree.

ALDRIN Yes, and they sure didn't instill a lot of confidence. This was the last alignment we were going to have, and we changed what we had by 0.3 degree. I guess that's to be expected, but I was sure hoping to have smaller ones than that. This indicated the kind of drift we had from the last alignment from the command module, and it was my understanding that these alignments were quite good — better than these torquing angles would indicate.

ARMSTRONG We're interested in finding out what the drifts were there; whether that was just an inability to calculate any biases and put them into the computer so that you could improve the platform up to what we normally would expect.

ALDRIN We had a manual lockon with the radar before we did this.

ARMSTRONG Yes.

ALDRIN We had P20 standing by, but we didn't use it at all.

ARMSTRONG We had a manual lockon and our radar needles and COAS agreed very well. This was your first chance to look at the transponder and all that stuff in operation.

COLLINS Yes. I recall I gave you some ranges. I didn't write them down.

ALDRIN It agreed with our values very closely.

COLLINS And they agreed with my state vector. I just wrote down one value which was fairly close to yours. When I had you at 0.72 miles on VHF ranging, my state vectors indicated 0.62.

ALDRIN That was close. Did we get that alignment finished? It seemed to me it took a little longer.

ARMSTRONG Yes, we took five marks on each star, and it did take us quite a while.

ALDRIN Yes, I would like to emphasize to subsequent crews to allow lots of time in their timelines when they're doing the alignments.

We made a practice early in training of leaving the TTCA switches disabled as much as possible, and the direct coils 4-jet active. I'm not sure everyone understands why you do that. It's a good sound thing, I think, to keep as many hand controllers out of the loop as you can.

ALDRIN (CONT'D) It makes troubleshooting far easier and it minimizes the number of problems you can get into.

ARMSTRONG It's just a basic difference in philosophy. Most of our Directorate takes the viewpoint that you leave everything on, and essentially everything is hot all the time. We took just the opposite approach; namely, we turned all the things off that we didn't think were contributing, particularly in the control system. We isolated that many more possible failures causing us difficulties enroute.

COLLINS We did the very same thing in the command module in that we used hand controller number 1 as a spare. We never powered it up and left it alone.

ARMSTRONG A lot of people didn't understand about disabling this and disabling this switch. It was really just a matter of preventing failures from getting to us in critical times.

9.0 DOI THRU TOUCHDOWN

9.1 COMMAND MODULE

9.1.1 LM DOI burn

COLLINS I didn't have any monitoring to do other than just confirming that they did it on time and that it was normal which it was.

9.1.2 AUTO maneuver to sextant tracking

COLLINS I did that, and lo and behold, the LM was in the sextant. This is a good exercise to do between DOI and PDI. It gives you an opportunity to make some sextant marks, make VHF marks, and then to see these marks incorporated into the state vector. It's a good end-to-end test of the whole system.

9.1.3 MSFN acquisition

COLLINS No problem.

9.1.4 Optics track - ease of tracking LM

COLLINS The LM was easy to track. AUTO optics worked well, and the optics drive was extremely smooth. When using resolve and in low speed, it was easy to take accurate marks on the LM. The LM, of course, got smaller and smaller, and out at about 100 miles, it became quite difficult to see

COLLINS (CONT'D) the LM through the sextant. The LM would appear to be just a tiny little dot of light which was easily confused with many other little dots of light on the optics. One trick that you can use is switch from AUTO to manual and slew the optics up and down and left and right. All the other little dots that are associated with the background of the surface will remain fixed, and the LM will then move across them; and you can pick out which little dot is the LM by the fact that the LM has motion relative to the background.

This technique works for another few miles, but I don't know how long I could have kept the LM in sight. I lost it prior to PDI when I switched from P20 to P00. My procedures called for me to do this, and in the simulator it worked quite well; however, in the real world at the instant I called P00, I went VERB 37, ENTER 00 ENTER. That stopped the P20 rate drive, and despite the fact that I was prepared for it and was looking through the sextant, the instant the computer went to P00 and the rate drive stopped, the LM just disappeared from view. It took off for parts unknown at a great rate of speed and disappeared to the 6 o'clock position in the sextant and at an extremely rapid rate. It was impossible to bring it back, and I never saw the LM again throughout the

COLLINS (CONT'D) descent or on the surface or during the ascent until after insertion.

9.1.6 Voice conference relay

COLLINS We didn't use the relay mode at all, although I had a little sticker made for panel 10 which showed the position of each switch. I think that's probably a good scheme because if you want the relay mode, you want it in a hurry; and you don't want to pull a checklist out, so I'd recommend that.

9.1.7 CSM backup pad

COLLINS Nothing to say about that. I, of course, used P76 to inform my computer that the LM had made the burn.

9.1.8 Monitoring LM phasing

COLLINS We didn't have a phasing burn.

9.1.9 Sextant marks

COLLINS I've covered those.

9.1.10 SPS setup

COLLINS For all burns, I was to go into P40 or P41 as appropriate. I then went to the point of turning on the gimbal motors and stopped short. I never turned on any gimbal motors, but I did feel that I could light the motor within

COLLINS (CONT'D) probably a matter of a few seconds after being informed that the LM had not made the burn.

9.1.11 Monitoring and confirming LM DOI

COLLINS After I went to P00, I lost the LM. This was a couple of minutes before PDI ignition. I just went ahead open loop. I followed my attitude timeline in hopes that I could see the LM again. I did my pitchdown maneuver that the flight plan called for. I did that as a VERB 49 maneuver, and it worked fine in that I had a good unobstructed view of the lunar surface, including the landing area and all that; but again I never saw the LM, so for future flights, I don't really know what to recommend. At the beginning of PDI on this flight, the LM was 120 miles in front of the command module, and touchdown was like 200 miles behind the command module; so the geometry is changing extremely rapidly, and there is no automatic program in the computer for helping you track. You had to abandon P20 prior to PDI, and I don't really have any helpful suggestions. The only thing I can say is to be aware of the fact that when P20 is terminated, the LM is going to depart very abruptly from the sextant field of view.

9.1.12 LM tracking

COLLINS However, if you are all poised and are in resolved medium speed and switch from AUTO to manual at the instant the computer switches from P20 to P00, there is a faint chance that you might be able to track the LM during PDI manually and during the descent. I tried to do this, not because there was any real requirement to do so, but just because I felt that it would be a good initial condition for an abort if I were able to see the LM in the sextant.

9.1.13 Lunar surface flag

COLLINS After the LM landed, I set the surface flag - - There was no evidence ever of any flash of specular light or anything like that off the LM. The LM, at distances of 100 miles, or so, is just another little light, little lunar bug that was indistinguishable on the background surface. The surface is pockmarked with little irregularities — light spots, dark spots — and with P20 driving so as to hold that background surface relatively constant and at those distances, you just can't pick the LM out.

9.2 LUNAR MODULE

9.2.1 Preparation for DOI

ALDRIN It was 40 minutes before DOI that we were scheduled to

ALDRIN (CONT'D) begin the P52 and we were about 2 minutes behind when we completed looking at the radar and VHF ranging and designated the radar down so that we could do the P52.

ARMSTRONG I don't think we had any difficulties with the DOI prep.

9.2.2 DPS/DOI burn

ARMSTRONG At DOI ignition, which was our first DPS maneuver, I could not hear the engine ignite. I could not feel it ignite, and the only way that I was sure that it had ignited was by looking at chamber pressure and accelerometer. Very low acceleration - -

COLLINS I would think under zero g, it would throw you against your straps, one way or the other.

ARMSTRONG We're pulled down into the floor with the restraint, and the difference between that and the 10-percent throttle acceleration was not detectable to me. However, at 15 seconds, when we went to 40 percent, it definitely was detectable.

ALDRIN On the restraints, I found that instead of being pulled straight down, the general tendency was to be pulled forward and outboard. So much so that this might have been a suit problem, as my right foot around the instep was taking a good bit of this load, being pulled down to the

ALDRIN (CONT'D) floor. It did feel as though the suit was a little tight. Prior to power descent, the problem was obscured from my mind, but it was aggravated somewhat by the restraint pulling down and forward.

ARMSTRONG I guess I noticed that last - I had expected a good bit of lateral shifting due to reports of previous flights.

ALDRIN I was able to lean over and make entries on the data card without pulling it down; but as you can see, when you do make entries on them, you make them sideways.

ARMSTRONG The cut-off was a guided cut-off. What about the residuals?

ALDRIN We burned both X and Z, and I'm sure they weren't in excess of .4.

ARMSTRONG It was less than 1 ft/sec, but I don't recall the tenths.

9.2.6 Trimming residuals

ARMSTRONG It's probably worth noting that the flight plan at this point does not adequately reflect the time requirements of the flight. I think the DOI rule in the flight plan says, "Trim V_X residuals."

ALDRIN So does your checklist.

ARMSTRONG That isn't right. This was a result of that orbital change that was put in late, and paperwork and so on just couldn't keep up with those last-minute changes. But, again, it shows that last-minute changes are always dangerous. You could follow the flight plan here and possibly foul up the procedure. Do you recall the VERB 82 values? 9.5 was perilune, I think.

ALDRIN Preburn for NOUN 42 was 57.2 and 8.5. We had 57.2 and 9.1 after the maneuver.

ARMSTRONG I guess we can't account for that.

ALDRIN No. The NOUN 86 that we got out of the thrust program also differed from what the ground gave us in the pad, primarily, in the Z-component that's loaded into the AGS; that pad value is 9.0, and the computer came up with 9.5. The coordinate frame that you load them in is frozen inertially, and if there are any discrepancies in the freezing of this, you will get a slightly different burn direction required out of the two guidance systems. I think that explains the larger AGS residual in the Z-direction of minus 0.7. I think we would have to have the guidance people verify that the difference in NOUN 86 produced that error in that direction.

9.2.9 Radar tracking

ARMSTRONG We had a good manual radar acquisition, and data from the radar agreed well with the VHF ranging information.

ALDRIN Again, we had P20 in the background, but we didn't use it. This was a manual lockon.

ARMSTRONG The radar was depowered to cool during the DOI to PDI phase.

9.2.16 Adequacy of procedures necessary to accomplish DPS maneuver

ARMSTRONG The platform drift check, a P52, was done against the Sun. This procedure seemed to work as we had planned; however, the variation in the data was somewhat larger that I would've guessed. Do you have those numbers?

ALDRIN Yes. The technique that we used was to compare what the computer thought the little gimbal or the inner angle was and to point the rear detent at the Sun. We'd compare that with what the actual middle gimbal was. Now we did this in PGNS pulse.

The way that we found to work out best was for Neil to tell me when, in the background, we'd have the AUTO maneuver display 50 18 in P52. We'd call up on top of that VERB 6 NOUN 20 or 22. And I'd have NOUN 20 up. As

ALDRIN (CONT'D) soon as Neil would say "MARK", I'd hit ENTER, record NOUN 20. Now the desire is to find out exactly what the computed value is in a close time period. So what I would do is hit the ENTER on the NOUN 20, visually recall what those numbers were, not write them down, but hit KEY RELEASE, which put me back to the 50 18 display. A PROCEED would recompute the numbers or maneuver. As soon as I would do that, those numbers would be frozen and the desired gimbal angles would be loaded in NOUN 22. Then it was just a question of my calling them up, and they should not change the time I hit ENTER to record the gimbal angle that we had until it was recomputed as a desired one that did not exceed 3 seconds. Of course, we had pretty low rates. So I think that the comparison didn't suffer any from a lack of proper procedure. We did find that the numbers were a little larger than we thought they would be. We had it worked out with the ground how we arranged the signs on the differences, so we'd subtract NOUN 22 from NOUN 20. The first one was 0.19; second one, 0.16; and the third one, 0.11. The GO/NO-GO value was 0.25. So we're a little closer to this than we had hoped to be.

ARMSTRONG The simulator is able to reproduce correctly the control modes that are required to fly it. It's an unusual

ARMSTRONG (CONT'D)

control mode wherein you fly to in pitch and fly from in yaw. While flying AOT, you depend on the other crewmember to assure you that the roll gimbal angle is staying at a reasonable value. The simulator was never able to simulate accurately what you would see through the Sun. We especially set up the AOT on the G&C roof (MSC) to look at the actual view. In addition, on the way to the Moon, we looked at the Sun with the telescope; looked through the CSM telescope with the Sun filter on to get used to what the filtered view of the Sun would look like in the optics. It's somewhat different in the telescope than in the AOT in color and general appearance. I can't account for that, but it is different.

I thought the numbers ought to be both closer to zero if we didn't have any platform drift, or closer together in either case. But we had quite a spread, so I'm not sure that the check in general is really as good yet as it should be. In other words, our variation was 0.08 degree between our various measurements. The limit on the GO/NO-GO is 0.25. So, we were essentially using up a third of our margin just in variation between our marks. That's not really a good enough procedure for this important check of the platform. This procedure, being a GO/NO-GO

ARMSTRONG (CONT'D) for the PDI needs additional work prior to the next flight.

There are some alternative methods of understanding platform drift, which we just did not have time to implement. Perhaps the next flights will be able to look at some of these alternatives and decide on an even better method than the Sun check.

ALDRIN We turned the propellant quantity on before DOI and I believe the quantity light came on at that point, which was expected as a possibility. Just recycling the switch off and back on again would extinguish the light. The values that we saw in fuel were about 94 and 95, which is what we generally saw in the simulator. The oxidizer value was somewhat lower than that. The simulator values were 95 and 95. I don't believe that there was sufficient time during DOI for these to settle down completely. They did approach the maximum numbers with a reading of approximately 94. Anyway, they weren't dancing around the way we might have been led to expect them to do.

ARMSTRONG The pre-PDI attitude prevented good S-band high gain contact. We had continual communications difficulty in this area until we finally yawed the spacecraft right

ARMSTRONG (CONT'D) between 10 and 15 degrees to give the high gain antenna more margin. This seemed to enable a satisfactory high-bit-rate condition, but it did degrade our ability to observe the surface through the LPD and make downrange and crossrange position checks. I don't think that our altitude checks were significantly degraded.

ALDRIN I can't explain why we had some dropouts there. The angles, 220 in pitch and yaw 30, are not ones that would lead you to believe they would give you trouble as far as interferences from the LM structure. It seemed to me that the initial lockon was not bad. There is a certain rain dance you had to go through each time you'd come around to acquire lockon. Each time you'd have LOS, we'd usually be on the OMNI's. Of course, there's a choice of forward or aft. Then you'd want to switch to SLEW and slew in the proper values for the steerable. Before LOS on the other side, the ground would like you to not break lock in the slew mode, because in some cases the antenna would then drive into the stops. So, approaching LOS, you'd switch to maybe the aft OMNI and then you'd slew in some new numbers.

We'd make use of pitch 90 and yaw zero, to keep the

ALDRIN (CONT'D) antenna away from the stops. Once you drive it to those values, then you'd have to set in new numbers.

Coming around on the other side, you'd maybe switch from aft to forward to pick up the ground. Once you picked them up, you'd switch over to SLEW and you might have the right values down there or you might have to tweak them up. In any event, the initial contact would be made on one antenna; and then, after you establish contact, you'd have to take the chance of breaking it to switch over to the high gain. Occasionally, we got the jump on them a little bit because the ground was talking to the command module. We saw that we had signal strength so I'd go ahead and try to lock on the S-band. It is a rather involved process that you have to go through. I didn't find that, if you left the antenna without an auto lockon signal, it would have a tendency to drive to the stops. At least from the indications, it didn't seem to be moving so rapidly that you couldn't, within several seconds if you knew what you were doing, stop it from where it was going and prevent it from hitting the stops.

We had two methods of computing altitude: one based on relative motion from the CSM and the other based on

ALDRIN (CONT'D) angular rate track of objects observed on the ground. We superimposed the two of them on one graph and rearranged the graph a little bit with some rather last-minute data shuffling to give us something that the two of us could work on at the same time and to give indication of what the altitude and its time history appeared to be. With the communications difficulties that we were experiencing in trying to verify that we had a good lockon at this point, I had the opportunity to get only about two or three range-rate marks. They appeared to give us a perilune altitude of very close to 50 000 feet, as far as I could interpolate them on the chart.

Those measurements give you altitude below the command module, essentially. And, of course, there are some modifications of the command module orbit, from the nominal preflight orbit that you expect. The numbers either have to be updated or you have to accept the error.

ARMSTRONG The measurements against the ground course were indicative of altitude directly above the ground.

ALDRIN The main purpose of the radar here was to confirm that we were in the same ballpark, the same kind of an orbit. And I think once you accomplish this several times, then

ALDRIN (CONT'D) it's adequate to go on with the truer altitude measuring device, which is from the ground.

ARMSTRONG The ground measurements were very consistent. If they made a horizontal line, it would indicate that you were going to hit a particular perilune, in this case, 50 000 feet (in the middle of the chart). They didn't say that. They were very consistent, but they came down a slope, which said finally that our perilune was going to be 51 000 feet. It steadied out at about 54 000 feet here at the bottom and our last point was 51 000 feet. This indicated that either the ground was sloping; and, in fact, it was about 10 000 feet lower than the landing site where we started (which is not consistent with the A-1 measurement that we made), or that the line of apsides was shifted a little bit. So actually perilune was coming a little bit before PDI.

So we were actually reaching perilune a little bit before PDI, which would tend to slope the curve that way. This was all very encouraging that we were, in fact, going to hit the guidance box so far as altitude was concerned from both measurements (the radar measurements and the ground measurements). But I was quite encouraged that

ARMSTRONG (CONT'D) these measurements, made with the stopwatch, were consistent, in fact.

ALDRIN When you're able to smooth the numbers and plot a reasonable number of them, your accuracy increases considerably. I think the preflight estimates were something on the order of a 6000-foot capability, and I think we demonstrated a much better capability than that.

9.2.17 PDI burn

ARMSTRONG Our downrange position appeared to be good at the minus 3 and minus 1 minute point. I did not accurately catch the ignition point because I was watching the engine performance. But it appeared to be reasonable, certainly in the right ballpark. Our crossrange position was difficult to tell accurately because of the skewed yaw attitude that we were obliged to maintain for COMM. However, the downrange position marks after ignition indicated that we were long. Each one that was made indicated that we were 2 or 3 seconds long in range. The fact that throttle down essentially came on time, rather than being delayed, indicated that the computer was a little bit confused at what our downrange position was. Had it known where it was, it would have throttled down later, based

ARMSTRONG (CONT'D) on engine performance, so that we would still hit the right place. Then, it would be late throttling down so that it would brake toward a higher throttle level prior to the pitchover.

9.2.24 Final approach and landing

ARMSTRONG Landmark visibility was very good. We had no difficulty determining our position throughout all the face-down phase of power descent. Correlating with known positions, based on the Apollo 10 pictures, was very easy and very useful.

ALDRIN As I recall, there was a certain amount of manual tracking being done at this time with the S-band antenna. During the initial parts of power descent, the AUTO track did not appear to maintain the highest signal strength. It dropped down to around 3.7 and the ground wanted reacquisition so I tweaked it up manually.

I got the impression that it was not completely impossible to conduct a manual track throughout powered descent. You'd not be able to do very much else besides that. I think it would be possible to do, if you had sets of predetermined values that you could set in.

ALDRIN (CONT'D) We did have S-band pitch and yaw angles immediately following the yaw maneuver, and those that were acquired at about 3000 feet. After the yaw, the S-band appeared to have a little bit better communications. It was just about at the yaw-around maneuver (trajectory monitoring from the DSKY up to that point agreed very closely especially in H-dot and V_I with the values we had on the charts). It was almost immediately after yaw around that the altitude light went out, indicating that we had our landing radar acquisition and lockon.

ARMSTRONG The delta altitude was — 2600 or 2700, I believe, is the number that I remember. I think it was plus 2600 or 2700. The yaw around was slow. We had inadvertently left the rate switch in 5 rather than 25, and I was yawing at only a couple of degrees per second as opposed to the 5 to 7 that we had planned. The computer would not hold this rate of say, 1 to 2 deg/sec. It was jumping up to 3 degrees and back, actually changing the sign and stopping the roll rate. It was then that I clearly realized that we weren't rolling as fast as was necessary and I noted that we were on the wrong scale switch. So I went to 25 and put in a 5-deg/sec command and it went right around. However, this delayed it somewhat and

ARMSTRONG (CONT'D) consequently we were in a slightly lower altitude at the completion of the yaw around than we had expected to be, so we were probably down to about 39,000 or 40,000 feet at the time when we had radar lockup, as opposed to about 41,500 that we expected to be.

ALDRIN There are no discrepancies noted in any of the systems that were checked throughout the first 4 minutes. The RCS was suprisingly high in its quantity indications. The supercritical did tend to rise a little bit after ignition and then it started back down again. I don't recall the maximum value that it reached. I guess the first indications that we had of anything going wrong was probably around 5 minutes, when we first started getting program alarm activities.

ARMSTRONG We probably ought to say that we did have one program alarm prior to this; sometime prior to ignition, that had the radar in the wrong spot. In any case, as I remember, we had a 500 series alarm that said that the radar was out of position, which I don't have any way of accounting for. Certainly the switches were in the right positions. They hadn't been changed since prelaunch. But we did, in fact, go to the descent position on the antenna and leave it there for a half a minute or so, ARMSTRONG (CONT'D) and then go back to AUTO and that cleared the alarm. After 5 minutes into descent, we started getting this series of program alarms; generally of the series that indicated that the computer was being overloaded. Normally, in this time period, that is, from P64 onward, we'd be evaluating the landing site and checking our position and starting LPD activity. However, the concern here was not with the landing area we were going into, but rather whether we could continue at all. Consequently, our attention was directed toward clearing the program alarms, keeping the machine flying, and assuring ourselves that control was adequate to continue without requiring an abort. Most of the attention was directed inside the cockpit during this time period and in my view this would account for our inability to study the landing site and final landing location during final descent. It wasn't until we got below 2000 feet that we were actually able to look out and view the landing area.

ALDRIN Let me say something here that answers the question that we had before about the AGS residuals on DOI. They were 0.1 before nulling and we nulled them to zero. X was minus 0.1, Y minus 0.4, Z minus 0.1, and we nulled X and Z to zero. Looking at the transcripts, we did have

ALDRIN (CONT'D) considerable loss of lock approaching PDI. And we did have to reacquire manually several times. It looked like we had some oscillations in the yaw angle on the antenna. The alarm that we had was 500 and we went to descent 1 and proceeded in the computer and then went back to AUTO again on the landing radar switch. This was prior to ignition and the ground recommended that we yaw right 10 degrees.

SPEAKER You had the rendezvous radar on?

ALDRIN The rendezvous radar was on, not through the computer, but through its own AUTO track.

ARMSTRONG We did not have the radar data feeding to the computer in the LGC position; but, apparently, if you have it in AUTO track, there's some requirement on the computer time. This is the way we've been doing it in all simulations. It was agreed on. We were in SLEW. Prior to this time, we'd been in AUTO track until such time as we started to lose lock in the pitchover. Then we went to SLEW, isn't that right?

ALDRIN Are you talking about the program alarms during the descent? We've passed the point of having the rendezvous

ALDRIN (CONT'D) radar in AUTO. We'd switched it over to SLEW at that point.

ARMSTRONG We were in SLEW with the circuit breakers in. Radar was turned on, but it was in SLEW. In the early phases of P64, I did find time to go out of AUTO-control and check the manual control in both pitch and yaw and found its response to be satisfactory. I zeroed the error needles and went back into AUTO. I continued the descent in AUTO. At that point, we proceeded on the flashing 64 and obtained the LPD availability, but we did not use it because we really weren't looking outside the cockpit during this phase. As we approached the 1500-foot point, the program alarm seemed to be settling down and we committed ourselves to continue. We could see the landing area and the point at which the LPD was pointing, which was indicating we were landing just short of a large rocky crater surrounded with the large boulder field with very large rocks covering a high percentage of the surface. I initially felt that that might be a good landing area if we could stop short of that crater, because it would have more scientific value to be close to a large crater. Continuing to monitor LPD, it became obvious that I could not stop short enough to find a safe landing area.

9.2.25 Manual control/pitchover

ARMSTRONG We then went into MANUAL and pitched the vehicle over to approximately zero pitch and continued. I was in the 20- to 30-ft/sec horizontal-velocity region when crossing the top of the crater and the boulder field. I then proceeded to look for a satisfactory landing area and the one chosen was a relatively smooth area between some sizeable craters and a ray-type boulder field. I first noticed that we were, in fact, disturbing the dust on the surface when we were at something less than 100 feet; we were beginning to get a transparent sheet of moving dust that obscured visibility a little bit. As we got lower, the visibility continued to decrease. I don't think that the altitude determination was severely hurt by this blowing dust, but the thing that was confusing to me was that it was hard to pick out what your lateral and downrange velocities were, because you were seeing a lot of moving dust that you had to look through to pick up the stationary rocks and base your translational velocity decisions on that. I found that to be quite difficult. I spent more time trying to arrest translational velocities than I thought would be necessary. As we got below 30 feet or so, I had selected the final touchdown

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ARMSTRONG (CONT'D): area. For some reason that I am not sure of, we started to pick up left translational velocity and a backward velocity. That's the thing that I certainly didn't want to do, because you don't like to be going backwards, unable to see where you're going. So I arrested the backward rate with some possibly spastic control motions, but I was unable to stop the left translational rate. As we approached the ground, I still had a left translational rate which made me reluctant to shut the engine off while I still had that rate. I was also reluctant to slow down my descent rate anymore than it was or stop because we were close to running out of fuel. We were hitting our abort limit.

9.2.28 Touchdown

ARMSTRONG: We continued to touchdown with a slight left translation. I couldn't precisely determine touchdown. Buzz called lunar contact, but I never saw the lunar contact lights.

ALDRIN: I called contact light.

ARMSTRONG: I'm sure you did, but I didn't hear it, nor did I see it. I heard you say something about contact, and I was spring loaded to the stop engine position, but I really don't know whether we had actually touched prior to

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ARMSTRONG (CONT'D) contact or whether the engine off signal was before contact. In any case, the engine shutdown was not very high above the surface. The touchdown itself was relatively smooth; there was no tendency toward tipping over that I could feel. It just settled down like a helicopter on the ground and landed.

ALDRIN We had a little right drift, and then, I guess just before touchdown, we drifted left.

ARMSTRONG I think I was probably overcontrolling a little bit in lateral. I was confused somewhat in that I couldn't really determine what my lateral velocities were due to the dust obscuration of the surface. I could see rocks and craters through this blowing dust. It was my intention to try and pick up a landing spot prior to the 100-foot mark and then pick out an area just beyond it such that I could keep my eyes on that all the way down through the descent and final touchdown. I wouldn't, in fact, be looking at the place I was going to land; I would be looking at a place just in front of it. That worked pretty well, but I was surprised that I had as much trouble as I did in determining translational velocities. I don't think I did a very good job of flying the

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ARMSTRONG (CONT'D) vehicle smoothly in that time period. I felt that I was a little bit erratic.

ALDRIN I was feeding data to him all the time. I don't know what he was doing with it, but that was raw computer data.

ARMSTRONG The computer data seemed to be pretty good information, and I would say that my visual perception of both altitude and altitude rate was not as good as I thought it was going to be. In other words, I was a little more dependent on the information. I think I probably could have made a satisfactory determination of altitude and altitude rate by eye alone, but it wasn't as good as I thought it was going to be, and I think that it's not nearly so good as it is here on Earth.

ALDRIN I got the impression by just glimpsing out that we were at the altitude of seeing the shadow. Shortly after that, the horizon tended to be obscured by a tan haze. This may have been just an impression of looking down at a 45-degree angle. The depth of the material being kicked up seemed to be fairly shallow. In other words, it was scooting along the surface, but since particles were being picked up and moved along the surface, you could see little rocks or little protuberances coming through this, so you

ALDRIN (CONT'D) knew that it was solid there. It wasn't obscured to that point, but it did tend to mask out your ability to detect motion because there was so much motion of things moving out. There were these few little islands that were stationary. If you could sort that out and fix on those, then you could tend to get the impression of being stationary. But it was quite difficult to do.

ARMSTRONG It was a little bit like landing an airplane when there's a real thin layer of ground fog, and you can see things through the fog. However, all this fog was moving at a great rate which was a little bit confusing.

ALDRIN I would think that it would be natural looking out the left window and seeing this moving this way that you would get the impression of moving to the right, and you counteract by going to the left, which is how we touched down.

ARMSTRONG Since we were moving left, we were yawed slightly to the left so I could get a good view of where we were going. I think we were yawed 13 degrees left; and, consequently, the shadow was not visible to me as it was behind the panel, but Buzz could see it. Then I saw it in the final phases of descent. I saw the shadow come into view, and

ARMSTRONG (CONT'D) it was a very good silhouette of the LM at the time I saw it. It was probably a couple of hundred feet out in front of the LM on the surface.

This is clearly a useful tool, but I just didn't get to observe it very long.

ALDRIN Here's a log entry: 46 seconds, 300 feet, 4 seconds after the next minute. Watch your shadow, and at 16 seconds, 220 feet. So I would estimate that I called out that shadow business at around 260 feet, and it was certainly large at that point. I would have said that at 260 feet the shadow would have been way the hell and gone out there, but it wasn't. It was a good-size vehicle. I could tell that we had our gear down and that we had an ascent and a descent stage. Had I looked out sooner, I'm sure I could have seen something identified as a shadow at 400 feet; maybe higher, I don't know. But anyway, at this altitude, it was usable. Since the ground is moving away, it might be of some aid. But of course, you have to have it out your window.

9.2.23 LPD altitude

ARMSTRONG The LPD was not used until we were below 2500 feet, and it was followed for some number of computation cycles.

ARMSTRONG (CONT'D) The landing point moved downrange with time as evidenced by successive LPD readings.

FCOD REP. Do you recall when you proceeded?

ARMSTRONG It was very shortly after we were going into P64.

ALDRIN We got P64 at 41 minutes 35 seconds; then you went MANUAL, ATTITUDE CONTROL.

ARMSTRONG I can't say whether that was before or after proceeding.

ALDRIN It wasn't too long after that, 41:35-P64, 42:05-manual attitude control is good, 42:17-program alarm. What I'm wondering is did the proceed have anything to do with maybe generating some more activity which would cause the program alarm? We weren't in 1668 at that point.

ARMSTRONG I have no recollection of that area.