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APOLLO 11 TECHNICAL CREW DEBRIEFING (U)

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HOUSTON, TEXAS

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1.0 SUITING AND INGRESS

1.1 SENSOR APPLICATION

ALDRIN The center lead dried out in flight. I was shaved in that area, but it dried out anyway. The one on my right chest, must have interfered in some way with the suit, because when the suit was taken off, there was a small laceration on the outside toward the rear of that particular sensor. I think that's been documented in the medical examination.

1.2 SUITING

ALDRIN We seemed to have plenty of pad in the time frame for suiting. We were sitting around suited up at least 20 minutes before moving out to the pad.

ARMSTRONG We had a reasonable amount of pad time to handle the little problems you might have at times. The timeline on suiting was good.

1.3 LIFE SUPPORT EQUIPMENT

COLLINS No problem with life support equipment or transportation out to the pad.

1.6 PERSONAL COMFORT

COLLINS The only personal-comfort problem I had was that my suit fit was too tight through the crotch area in the region of the UCD. During CDDT, I was really very, very

[redacted]

[redacted]

COLLINS (CONT'D) uncomfortable for a couple of hours with the UCD pushing into my crotch area. This problem goes back to that first suit fit at the factory. ILC is very concerned about the mobility inside a pressurized suit, and I think they went a little bit overboard in cutting that thing on the tight side. I didn't really put the UCD on; you know what I mean. They've got a house UCD up there, and you sort of slap that inside the suit and then you get a fit check. The only time it hurt me was when I actually had the UCD securely held and I was strapped into the couch and my legs were up. The only thing I could suggest is that when anybody goes to the factory, they take their own UCD and put the damn thing on and, during that fit check, go through some kind of an imitation of the watch position with the correct leg-to-body angle which you have in that couch for launch position. Put your own UCD on and see whether that's going to be comfortable or not. I fiddled and diddled with it between CDDT and launch, and it was still fairly uncomfortable for launch; for CDDT, that damn thing almost did me in. Don't let them cut the suit too tight, and try to get a good fit check at the factory.

[redacted]

[redacted]

1.5 ELEVATOR AND FLIGHT DECK

ALDRIN — From the center-couch position, it's a very pleasant time period because I'd sit in the elevator and walk around up there on the flight deck and contemplate just about everything, including the outside world.

CDDT was a very pleasurable experience, looking out over the whole beach.

1.8 INGRESS

ARMSTRONG — While we were completing the countdown procedures, the number 2 rotation hand controller was raised to the launch position. At that point, it somehow managed to attach itself to the shock attenuator release on the lower left strut. It released after a good bit of work and coordination between Mike and Fred, the BCMP. It was relocked. No new procedure there; it just requires care and properly installing those handrests to avoid a recurrence of that problem.

It would be well for the BCMP to assure himself that he knows how to relock any one of the strut releases that might come disengaged in this time period.

COLLINS — The crew should know about the strut softeners just in case one of them gets pulled loose inadvertently in

[redacted]

[redacted]

COLLINS (CONT'D) flight. You should know how to reset them. This should be added to their list of things to learn.

ALDRIN I don't feel that we really need life preservers on for launch. They interfere with what little mobility you have. It appears to me that in any abort condition you don't need to make use of the life preservers and that it would be a fairly simple thing to get them out of the little pouches that are in the L-shaped bag.

1.10 COMFORT IN COUCH

ARMSTRONG Temperature was good in our spacecraft during both CDDT and launch. I didn't suffer any of the abnormally low temperature conditions that had been reported on some of the previous flights.

COLLINS The reason was that we were flowing glycol through the secondary loop. I believe this was the first time they tried this. The secondary glycol loop pump was on and it was flowing through the suit circuit heat exchanger. I don't know what Apollo 10 did, but I remember Apollo 9 described this deal of going bypass on the heat exchanger for 15 seconds and all that. We didn't have to mess with that at all. Our procedure worked very well. I don't know who thought it up to use the secondary loop;

[redacted]

COLLINS (CONT'D) but it made the system very comfortable, and I recommend that they continue to do it the way we did it.

1.12 VIBRATION OR NOISE SENSATIONS

COLLINS They called out everything. Every time we were going to feel something, they were very good about calling it up.

ALDRIN We did observe some booster valving. They called it out, and it was quite obvious when there was valving taking place.

[redacted]

2.0 STATUS CHECKS AND COUNTDOWN

2.2 COMM VERIFICATION

ARMSTRONG Our prelaunch COMM checks were all reasonably good.

ALDRIN It's unfortunate that, because of the location of that center panel, we do have to split the COMM and take the center couch off the pad COMM. I can't say we really suffered much on account of it, but it would be nice if there were some way to make that switch position change — either figure out some way to loosen the belt and get back up there and readjust the COMM, or change positions in some way.

2.4 G&C VERIFICATION

ARMSTRONG GDC align was good.

2.5 GROUND COMMUNICATIONS AND COUNTDOWN

ARMSTRONG Communications were excellent throughout the prelaunch phase. We had no problems with controls and displays that I can recall.

2.10 CREW STATION CONTROLS AND DISPLAYS

ALDRIN They had that attenuation strut positioned very nicely so that I could see the altimeter. On the simulator it's very difficult from the center couch to see the altimeter. They had rotated this handle on the X strut on the left of my seat so that I could see just about the entire altimeter, which is good. I think that ought to be a standard procedure.

[redacted]

[redacted]

2.11 DISTINCTION OF SOUNDS IN THE LAUNCH VEHICLE

COLLINS They called all those out. I thought they did an excellent job of warning us of what to expect. Not that it really makes a heck of a lot of difference because you got to sit there anyway, but it's nice to know.

2.12 VEHICLE SWAY PRIOR TO IGNITION, SWING ARM RETRACT

ALDRIN Well, it wasn't much of a jolt when that swing arm moved out and came back in again.

ARMSTRONG No. It was reasonably smooth. I didn't really note any vehicle sway prior to ignition.

[redacted]

[redacted]

3.0 POWERED FLIGHT

3.1 S-IC IGNITION

ALDRIN There really wasn't much of a cue at all that I could recall. I can't remember feeling much of anything before T zero. How about the rest of you?

COLLINS No. It was very quiet. You could feel the engines were starting up because there was a low amplitude vibration.

3.2 COMM AUDIBILITY AT IGNITION

ARMSTRONG COMM audibility at ignition was good. Noise vibration intensity prior to release was minor.

3.3 NOISE/VIBRATION INTENSITY, SHOCK AND CREW SENSATION PRIOR TO RELEASE

COLLINS There was low noise, moderate vibration. I'd say light to moderate vibration. I didn't really notice much vibration until we released. Crew sensation prior to release is just about what you'd expect from Titan or from previous crew briefings on the Saturn V. It was quite mild prior to release, I thought.

[redacted]

[redacted]

3.4 HOLDDOWN RELEASE

ARMSTRONG Now, release itself, I think we have a little bit of difference there. I felt that I could detect release, and I think your comments were that perhaps you weren't quite so sure what the moment of release was.

3.5 LIFT-OFF

ALDRIN I can't recall any sudden change that occurred at that point, but it seems to me that there was a gradual sensation of upward movement. Then the vibration - well, it was more of an oscillation, I think, than a vibration. It certainly wasn't just longitudinal; it was a fair amount of motion in both the Y-direction and in the Z-direction. I don't know what the frequency was, but I'd call it a couple of cycles per second. It was a little surprising to me, and this started rather suddenly.

COLLINS About the time of lift-off, that's what I thought. I couldn't detect lift-off by the conventional means of sensing a transverse acceleration. However, the moment of lift-off was very apparent because this vehicle, which had been rigidly held, was now suddenly released and we were getting all manner of oscillations - X, Y, and Z, as near as I could

[redacted]

COLLINS (CONT'D) tell. All of a sudden, this thing changed character from a static to a dynamic situation, and that was what I would call the instant of lift-off.

ARMSTRONG Concerning the noise/vibration intensity at lift-off, it was my impression that the combination was rather severe until approximately the time of "Tower clear," at which time there was a significant decrease.

COLLINS Yes, but would you say noise? I would say vibrations. I thought the noise level was much less than I had expected. The vibration was more.

ALDRIN How about a rumbling? That is physically felt as much as heard.

COLLINS You don't hear it in your ears. You feel it in your whole body. Whether that's noise or whether that's vibration, I don't know.

ARMSTRONG I would agree that the noise was low level.

COLLINS In terms of interference with communications, though, I think you would also have to say that it is low level.

ARMSTRONG That's true.

[redacted]

ALDRIN Subjectively, the first 10 to 12 seconds until tower clear took longer than I thought it would. I would have thought a long 10 or 12 seconds would have been over just like that.

COLLINS It was a long, long time before anybody gave "Tower clear."

ARMSTRONG It was right on time. I was looking at the event timer.

COLLINS Was it 14 seconds - something like that to tower clear?

ARMSTRONG I'd say 12.

ARMSTRONG I thought that the COMM came through quite clear.

ARMSTRONG Instrument observation was no problem during this time. In fact, some were a lot better because the lighting in the cockpit is better than in the simulator.

ALDRIN But we all agree that there was a decrease in the vibration, oscillation, or rumbling that could possibly be attributed to reflections off the tower.

ARMSTRONG I think maybe it's just reflections off the ground.

COLLINS Ground reflections.

ARMSTRONG It goes away at about the tower-clear time.

ARMSTRONG I thought they were.

[redacted]

[redacted]

3.13 MACH 1 AND MAX g NOISE LEVELS

ARMSTRONG Well, I think I was surprised at how little these were apparent to me, and particularly Alpha. Alpha never came off zero throughout the launch, and I wondered if they were operating.

3.14 CONTROL RESPONSE IN HIGH g REGION

ARMSTRONG It was as smooth as glass going through the high g region.

ALDRIN What causes it, we don't really know, but it could be the vehicle length away from the ground; characteristic length, or whatever you call it.

3.6 LAUNCH VEHICLE LIGHTS

ARMSTRONG Launch vehicle lights, roll program, pitch program, roll complete were on time, as were the rate changes. My impression in the seat throughout this phase, as well as the subsequent first stage, was that of going over rough railroad tracks in a train in which vibrations occur in all three axes.

COLLINS That was a rougher ride than I expected.

ARMSTRONG There were sharp bumps in each of the three axes periodically.

COLLINS Yes, that's right, and the gain of the system was pretty high, also.

[redacted]

[redacted]

3.11 CABIN PRESSURE (DECREASE)

COLLINS The valves worked as advertised and started decreasing as scheduled.

ARMSTRONG You can hear those valves relieving, I think, from all three crew stations.

ALDRIN While they were relieving, you couldn't hear too much else.

COLLINS I didn't think it was that bad.

3.15 EMERGENCY DETECTION SYSTEM

ARMSTRONG No problems.

3.16 VEHICLE RESPONSE TO GIMBALING

ARMSTRONG The outboard engine gimbaling was not really noticed.

3.17 NOISE LEVEL VARIATION

ALDRIN We were anticipating that, but it was just a motion as I recall. There were several little jolts to your relaxing of the four g's. That's how I recall it.

COLLINS I would say that we were well briefed on that. I mean there weren't really any surprises.

3.22 DISTINCTION OF SOUNDS AND SENSATIONS

ARMSTRONG There were sounds and sensations during the staging.

[redacted]

[redacted]

3.23 S-IC TWO-PLANE SEPARATION

ARMSTRONG Skirt SEP, as I recall, was heard or felt or some observable characteristic, in addition to the light going out at the time, and I can't remember if it was a bump or a noise, but there was in addition to the fact.

ALDRIN This would give you a clue if the lights were not working, if something had happened at that point.

3.24 S-II ENGINE IGNITION

ARMSTRONG S-II engine ignition went smooth.

3.25 GASEOUS PRODUCTS

ALDRIN Now, that stuff that went oozing forward.

COLLINS That staging - well, it was just like staging on the Titan. It seemed like to me that at staging the windows lit up with yellow, almost like a flash of light.

ALDRIN Well, let's see - S-IC. I didn't like it either, because we were tossed forward, and I couldn't look out the hatch. You're the only one that had a window at that point. I don't remember anyone saying too much about that. We'll get to that a little later on the S-IIC.

[redacted]

[redacted]

3.26 POGO OSCILLATIONS DURING S-II BOOST

ARMSTRONG I didn't note any.

COLLINS Smooth - smooth as glass.

ARMSTRONG S-II ride was the smoothest I've ever seen.

COLLINS It really was. It was beautiful.

3.27 INITIATION OF ITERATIVE GUIDANCE MODE

ARMSTRONG Guidance initiate was as expected.

COLLINS Tower went as advertised.

3.28 Q-BALL TRANSIENTS AT S-II IGNITION

ARMSTRONG No Q-ball transients were noted at S-II ignition. I may have been looking at them.

3.30 SCALE CHANGE, VEHICLE RESPONSE, AND OBSERVATION

ARMSTRONG Scale change was not utilized. There were no unusual noises or vibration at this point in the flight. It was all smooth.

3.32 SECOND IGM PHASE RESPONSE

ARMSTRONG The PM ratio shift was observable. You could feel g's decrease.

[redacted]

3.33 LET AND BPC JETTISON

ARMSTRONG Tower jettison - you could watch it go. There wasn't any question about it.

3.34 GUIDANCE - INITIATE

ARMSTRONG Guidance initiate was about as expected. The S-IVB staging and engine cut-off were ...

ALDRIN Anybody notice any exhaust coming back on the windows when the BPC went? It seemed to be a pretty clear separation.

ARMSTRONG I didn't note any. I wasn't looking out the window at that point.

COLLINS I was, and I didn't notice any. Those windows, 2 and 4 were clear. They didn't have any deposits on them.

3.37 S-II/S-IVB SEPARATION

COLLINS The staging sequence is a long slow one. I'm sure it was about equal to the simulated values we were used to. It seems like a long time in flight to get the S-IVB ignited. The S-IVB guidance was as expected.

ALDRIN Any comment about the gimbal motors coming on?

ARMSTRONG The motors were put on at 6 minutes and all came on.

[redacted]

[redacted]

COLLINS Well, you can confirm them with the fuel cell flows, and that's not something that reaches out and grabs you. If you watched those meters carefully, you could definitely say that all four gimbal motors came on.

ALDRIN I was looking at this sort of thing later. I found that observing them several times right at the time they were coming on, you look at the current and you see that it's a fairly small but observable change in the fuel cell current, and then just about a half second later you begin to see the rise and flow. You can catch both of them if you look at the current first and then the hydrogen and oxygen flow.

COLLINS I just looked at hydrogen flow. They say that you have to be watching closely. If you are, you can definitely say that they all four came on.

3.42 AUXILIARY PROPULSION SYSTEM

ARMSTRONG That was particularly noted during powered flight.

3.43 POGO OSCILLATIONS OF S-IVB

ARMSTRONG No POGO oscillations.

ALDRIN There's a rougher ride on the S-IVB than on the S-II.

[redacted]

[redacted]

ARMSTRONG No doubt about it.

COLLINS I wouldn't call it POGO, but it just wasn't as smooth.

ARMSTRONG It was a little rattly all the time.

COLLINS It was a lot smoother than Stafford described his ride. I think we had a different S-IVB than he had.

ALDRIN PU shift was noticeable.

COLLINS That was very noticeable.

ALDRIN That was quite a jolt. About as much as one engine out.

ARMSTRONG That's probably about right.

ALDRIN About the same change in thrust.

3.44 SEPARATION LIGHTS

ARMSTRONG Separation lights as advertised.

3.45 DISTINCTION OF SOUNDS AND VIBRATIONS

ARMSTRONG Sounds and vibrations we've commented on.

3.50 COMMUNICATIONS

ARMSTRONG Communications with the ground for the go/no-go went without a problem. There was a short time period in there when we didn't hear anything. I think we gave them a call just to make sure that we still had COMM.

[redacted]

 [redacted]

ALDRIN Following the trajectory throughout boost was quite easy with the card that we had, and I found that we were within 20 to 30 feet per second V_I, and it seems to me, 5 feet per second most of the time H-dot. Guess the altitude was a little lower, wasn't it? We might note that we did elect to have this trajectory card over part of the DSKY, which did cover up some of the status lights. The right-hand column of status lights were covered up. The ones in the LEB were observable in case any of those came on.

ARMSTRONG Engine cut-off was smooth, and we were standing by to do a manual cut-off with the LV stage switch should cut-off not occur on time.

ALDRIN We didn't seem to elbow each other quite as much as we had in some simulator runs. The suits are big and the elbows kind of stick out, but I didn't notice any interference with our activities.

COLLINS The only interference I noted was that Neil's suit pocket interfered with the abort handle. He was worried about that, and I was worried about that.

ARMSTRONG The contingency sample pocket where it was strapped on the leg was riding right against the abort handle. We adjusted that as far to the interior of the thigh as we possibly

[redacted]

[redacted]

ARMSTRONG (CONT'D) could to minimize the interference, but we still were continually concerned with the fact that we might inadvertently press that thing against the top of the abort handle.

ALDRIN Before we go on, did you all note any numbers? I have written down here: apogee 103.9, perigee 102.1.

COLLINS They tell me that they have better sources.

ALDRIN I'm just wondering why in our checklist we're not able to write down the CSM weight and gimbal motor numbers. We certainly ought to know what those are before flight and just confirm that those numbers have been set in.

COLLINS I don't know why you fool with them at all. They come up to you on the first PAD prior to the first burn.

ALDRIN Everybody in the world knows what they are, and they ought to be in the checklist.

COLLINS I don't even know where they list them. The only other thing that I had on the launch phase was there was some peculiarity in the servicing of the oxygen quantity. Oxygen tank number 1 had 90 percent on my gage, and oxygen tank number 2 had 95 percent with a 5 percent differential, and they kept talking about some mission rule which allowed a maximum of

[redacted]

[redacted]

COLLINS (CONT'D) 4 percent differential. All this was a little confusing to me. It sounded as if we got shortchanged in oxygen tank number 1. I'm not sure if that's true, and it even occurred to me that there might have been a slight leak in tank number 1. I'm sure that there wasn't, or they wouldn't have launched us. A few words on that subject would have been nice. I think as a general rule if the loadings are not nominal, it would be nice to let the crew know that they're

COLLINS a little off nominal. It sounded like we launched in violation of the launch mission rule.

ARMSTRONG Differential between oxygen tanks?

COLLINS Yes. It was 5 percent, and it sounded like the mission rule was 4 percent MAX. And I was perfectly happy to launch with that if that was the only problem. I didn't want to bring it up on the loop and make a federal case out of it. On the other hand, it would have been nice to know.

ARMSTRONG It only took 1 hour and 15 minutes to get through a perfectly normal launch with no problems.

COLLINS We started late.

[redacted]

[redacted]

4.0 EARTH ORBIT AND SYSTEMS CHECKOUT

ARMSTRONG It appeared that the platform was in reasonably good shape and its values compared favorably with the MSFN ephemeris. Everything went smoothly.

4.2 POST-INSERTION SYSTEMS CONFIGURATION AND CHECKS

COLLINS The insertion checklist is fine, as far as I'm concerned. After the insertion checklist, the items in the checklist on page L-2 and L-9 need some work to get them in the proper sequence.

ALDRIN It's pretty hard to follow through on the time with all those things happening according to the time schedule that's on there, especially when you get down to the LEB.

COLLINS The one who goes down to the LEB is sort of jumping from one place to another and back and forth. Some improvement could be made on the order in which those items are. I sort of got lazy and decided not to fight the checklist world and I just had my own order in which I was going to do them regardless of the order of the checklist. The follow-on crews ought to look at this section and have things rearranged to their liking for a minimum amount of moving around.

ALDRIN For example: Step 7 on 2-9, the 20 minutes ECS postinsertion configuration, we were doing other things at that time and I

[redacted]

[redacted]

ALDRIN (CONT'D) don't believe that we were in position to be doing that until after we passed Canaries. Each person is sort of operating on his own. We know we're going about in the various systems checks, and that doesn't fit into a real good timeline.

COLLINS An example here on page L2-8, item 4, EMERGENCY CABIN PRESSURE valve to BOTH. That check is made prior to anybody's going into the LEB. That's impossible to do; obviously, you have to be down in the LEB to see it. The man who goes down to the LEB — if he goes through steps sequentially as written in the checklist — would start jumping from one place to another back and forth. Some improvement could be made in the order. Now, I sort of got lazy and decided not to fight the checklist world. I just had my own order in which I was going to do them regardless of the order that is in the printed checklist. But to really be precise about it, the following crews ought to look at this little section and get things rearranged to their liking and for a minimum amount of moving around.

ALDRIN Yes, well, for example, that step 7 on 2-9: During 20 minutes of ECS postinsertion configuration, we've been doing other things at that time. I don't believe we were in

[redacted]

[redacted]

ARMSTRONG (CONT'D) position to be doing that until after we passed Canaries. It was approaching 30 minutes, it seemed to me, yet we had done several other things ahead of that point. Each person is sort of operating on his own. We know what we're going about in the various systems checks, and it doesn't fit into a good timeline.

COLLINS This is a small example here: Page L2-8, item 4, EMERGENCY CABIN PRESSURE valve to BOTH. That check is made prior to anybody's going in the LEB. That's impossible to do. Obviously, you got to be down in the LEB to see it. Yet it's listed prior to the time the CMP goes to the LEB for the main regulator check. Just little things like that, the sequence here is crazy. And, as I say, I was lazy and didn't get it straightened out in the checklist world. I just went through it in my own fashion. But to be precise about it, the following crew should go through this one time and rewrite this in a more efficient fashion.

4.3 INITIATION OF TIME BASE 6 - AWARENESS

ARMSTRONG Okay. Initiation of time base 6. I think we'll postpone that.

4.4 ORDEAL

ARMSTRONG Now then, ORDEAL: We used a system where the CMP was already

[redacted]

[redacted]

ARMSTRONG (CONT'D) in the LEB and under the couches, released the latch on the ORDEAL, and let it float up to the CDR who was still strapped down in the couch that was no problem.

COLLINS Here again, that probably should be a checklist item if people want the CMP to do that, as we did it. Then it probably ought to be written in his list of things to do.

ARMSTRONG That worked well for us, I think.

COLLINS Worked fine.

ALDRIN Optics Cover Check.

COLLINS The only thing I can say as a general rule is it goes back to this thing about becoming ill. And that is, if you're really worried about anybody becoming ill, the guy you're going to worry about is the one who's rattling around down in the LEB. In our flight, that was I and I was also the one who would be doing the transposition and docking. So I was trying to move around with minimum head movements and go minimum distances and so forth. But on the other hand, if you're convinced you're not going to be sick, well then, all those things go away. It's sort of a nebulous area. I don't know what to do about it.

[redacted]

[redacted]

ALDRIN Well, it's something you can't afford to get ahead of yourself and be moving around too fast. If there's any question at all and I think we all played it very cautiously until each of us in our own particular way realized that it was just no problem. As we adapted to it, we could go about any kind of movement that we wanted without any particular concern. But the stakes are pretty high and you can't afford to let these things get the best of you.

4.5 OPTICS COVER JETTISON (DEBRIS)

COLLINS I heard a little noise, but I saw no debris and I could not verify that they had jettisoned. I looked through both instruments and I couldn't see that they had jettisoned.

4.6 SCS ATTITUDE REFERENCE COMPARISON

COLLINS Okay.

ARMSTRONG It went well. No problems.

4.7 SM AND CM RCS

ARMSTRONG We did hot RCS checks on the service module RCS prior to TLI. The intent here was to assure ourselves that we did, in fact, have an operable control system and that our hand controllers could, in fact, talk to something before committing ourselves to a lunar trajectory. We did that in

[redacted]

[redacted]

ARMSTRONG (CONT'D) MINIMUM IMPULSE and it was extremely difficult to hear the thrusters firing. It was impossible to read an effect on any indicator in the cockpit.

COLLINS This is with helmet and gloves on.

ARMSTRONG Helmet and gloves on. So we were pleased when the ground said they could, in fact, see the thrusters firing. We did have to repeat one which they didn't see.

ALDRIN I don't recall why we had the helmets on at that point.

ARMSTRONG We didn't take them off?

COLLINS We took them off and we put them back on.

ALDRIN That should have been with at least one man with his helmet off so he could hear it.

ARMSTRONG Right.

COLLINS Well, on the other hand, if you scheduled it over the States and the ground verifies it, you don't much care.

ARMSTRONG I was satisfied that we did, in fact, prove the point that we wanted to prove.

[redacted]

[redacted]

4.8 COAS INSTALLATION AND HORIZON CHECK

ARMSTRONG Unstowage; COAS installation: I don't recall any points there.

4.9 UNSTOWAGE AND CAMERA PREPARATION

ARMSTRONG We had the TV camera preparation also in the same time period; any comments there?

COLLINS Well, again, this camera preparation probably should be written into the checklist on page L2-9, in a bit more detail than it is.

ALDRIN Well, on 2-13 in detail, but do you want it sooner?

COLLINS Well, this is when you're unstowing it, because really all it says is cameras and that really means the 16-mm plus the 70-mm and the various lenses. You hand them up and you get the bracket from Neil. It's really sort of an assembly process there. This is sort of a dealer's choice, but I suggest that the following crews give some thought right on page 2-9 to deciding what cameras they want to unstow or what they want to do with them and how they're going to do it. Otherwise, they're going to have another trip back down to the LEB which really isn't necessary.

[redacted]

[redacted]

4.10 DOCKING PROBE

ARMSTRONG I think they're attempting to recall anything that might have gone abnormally.

COLLINS There were no findings in that docking probe.

4.12 COMMUNICATIONS

ARMSTRONG Communications were more or less in and out in earth orbit. Sometimes there was quite good S-band through the various stations; othertimes, it was only medium.

4.14 COMMENTS ON EARTH-ORBITAL OPERATIONS

ARMSTRONG Any comments on the earth-orbit operations?

COLLINS I think, in general, that's a very nice timeline. We hammered away at it enough to where we're only checking those things that really should be checked and there's plenty of time available to check them in a leisurely fashion. I think that's a nice timeline.

ALDRIN How about the alignment? On the Saturn?

COLLINS The platform alignment?

ALDRIN Yes, torquing angle we got from the ground and the alignment they gave us -

COLLINS Yes, I didn't know what to say about that. I think that's probably within normal tolerance.

[redacted]

ALDRIN Yes.

COLLINS The alignment at ORB RATE is no problem as other flights have reported.

4.18 EMS DELTA-V

ARMSTRONG Okay. EMS DELTA V. No problems.

4.19 SCALE CHANGE

ARMSTRONG Scale change, systems, engine alignments, GO for TLI, and then - -

COLLINS Glad to get it - no problems.

ALDRIN Well, I think it's worthy to note that we did intend to have the TV camera out. It did not seem to crowd the timeline, trying to get those pictures coming up on the West Coast. We still seemed to have a very comfortable approach to TLI.

COLLINS That's right. Of course, that's where we said we weren't going to fool with the television if we were rushed or behind the timeline.

4.23 DRIFT TEST

ARMSTRONG The drift test has to do with your alignment, I guess. - and also with the GDC drift, which was acceptable.

[redacted]

4.24 CREW READINESS AND COMFORT

ARMSTRONG I think we were ready for TLI. We were unrushed and had no problems there.

4.25 SUBJECTIVE REACTION ON WEIGHTLESSNESS

ARMSTRONG Well, perhaps a little bit of fullness in the head.

ALDRIN I didn't notice that quite as soon coming on as in Gemini.

ARMSTRONG Yes, I didn't feel that it was as marked as I had remembered.

COLLINS It's so slight, that if you have anything else in your mind, you just try to ignore it. I mean, it's not any big effect.

ALDRIN Well, there's the feeling that your face tends to lift up a little bit.

COLLINS Yes, it does. Your eyes are puffy.

ARMSTRONG A sensation of head-down position. I guess I had that sensation and expected it and thought it ought to be there, because we were head-down.

ARMSTRONG Vertigo spatial disorientation.

ALDRIN No problems.

COLLINS None.

[redacted]

[redacted]

ALDRIN As far as I was concerned, there wasn't anything really to be alarmed about in the least. I do think that the fact that you've been through it makes a good bit of difference. There was a good bit made of this sort of thing before the flight, and I think someone who had not flown before would have been a little bit overly concerned.

ARMSTRONG Yes, we were probably a little bit overly apprehensive about this area, because there had been so many comments on it in recent flights; we just didn't run into any problems.

[redacted]

[redacted]

5.0 TLI THROUGH S-IVB CLOSEOUT

5.1 TLI BURN MONITOR PROCEDURE

ARMSTRONG The procedure went very well.

COLLINS Except yaw.

ARMSTRONG No, the yaw was perfectly on, but the pitch showed approximately a 1-1/2-degree bias from the value that we would have expected. That is to say, with the ORDEAL set in a LUNAR/200 configuration, and being at the proper point on the minute each minute prior to ignition. The pitch attitude was indicating about 1-1/2 degrees higher, that is, 1-1/2 degrees to the right or plus 1-1/2 degrees from zero. We expected approximately zero. I think this would be wise to look at that carefully with DCPS training guide with respect to the adequacy of that procedure and see where that little bit of difference occurs. Other than that, the TLI monitoring went just as expected.

ALDRIN But that was an instrument that was used to make changes if we were in control. The closing of the loop was really the observation of the H-dot which was surprisingly close. At each 30-second period, we closed the DSKY and looked at the H-dot and it was amazingly close. Of course, there get to

ALDRIN (CONT'D) be some pretty good H-dots at about 4 minutes and 30 seconds at about 2200 H-dot; and I don't think it was off more than 10 ft/sec at that point, so much closer than we've seen in any simulations, right in the groove.

ARMSTRONG Had we gone to manual TLI, then we would have probably been a little bit off in pitch. I think we had soon seen that our H-dot was beginning to get out of bounds and we made a correction, but we should understand that a little better.

5.2 S-IVB PERFORMANCE AND ECO

ARMSTRONG S-IVB performance and engine cut-off were outstanding.

ALDRIN The time of the burn.

ARMSTRONG Burn time was not quite book value, there. Did we write that down in our checklist? Burn time? Give them a burn-status report?

ALDRIN As I recall, it was a little longer than normal.

ARMSTRONG No, as I remember, it was like a couple of seconds off in burn time, but I just don't recall now what the difference was; but other than that, it went very well.

ALDRIN Let me just note some numbers here that was recorded at freezing the DSKY after cut-off and you are bound to miss

ALDRIN (CONT'D) that by a couple of seconds. The expected V_I was 35575 and I reported 35579; the H-dot expected was 4285 and I have 4321; and, of course, H-dot was building fairly rapidly and that's not quite a mile a second, so the expected altitude was 174 and we read 176. The EMS was 3.3 plus.

ARMSTRONG Yes, we knew, when the EMS showed only 3 ft/sec off in a 10 000-ft/sec burn, it was going to be pretty good to us.

5.3 UNSTOWAGE AND PREPARATION OF CAMERAS

ARMSTRONG No problem.

5.4 S-IVB MANEUVER TO SEPARATION ATTITUDE

ALDRIN It was right on schedule and no comment.

5.5 PRESEPARATION CONFIGURATION

ALDRIN No problems.

5.6 MCC GO/NO GO FOR PYRO ARM

ALDRIN Well how about that high O_2 flow anomaly that I think the ground picked up?

ARMSTRONG Yes, I guess that's right.

5.9 S-IVB/IU CONTROL SYSTEM PERFORMANCE

ARMSTRONG Good.

[redacted]

5.11 S-IVB TANK PRESSURES

ARMSTRONG Good.

5.12 EDS OPERATION

ARMSTRONG All on time.

5.13 PYRO OPERATION

ARMSTRONG No problem.

5.14 SEPARATION FROM SLA

COLLINS The only comment on separation from SLA is the general comment about the EMS during the separation, turnaround, and the docking was that the EMS numbers got confused. The EMS got jolted and did not record some acceleration that it should have or it recorded some that it should not have; I don't know which is the case. I used the EMS as an indicator after turnaround as to how much DELTA-V to apply thrusting back toward the booster. When I got to that stage of the game, the EMS numbers made no sense at all. They were 1-1/2 ft/sec in error, and at docking, that situation continued. The EMS number that I jotted down at docking was 99.1. There's no way that the EMS could read 99.1 at docking.

As I recall, I thrusted away from the booster until the EMS DELTA-V counter read 100.8, just like the procedures said.

[redacted]

[redacted]

COLLINS (CONT'D) Then I thrusted minus X until the DELTA-V counter read minus 100.5. I think I thrusted plus X until it read minus 100.6. The point where the EMS was in error came after that. That's what I don't understand. When I completed the turnaround maneuver, the EMS should have read minus 101.1 and it didn't. It read down in the 90's. At docking, when it should have read 101 plus, it read 99.1. So there is a funny there in the EMS.

5.15 HIGH GAIN ANTENNA ACTIVATION

ARMSTRONG That took us quite a while.

COLLINS You did that later.

ALDRIN Yes, we didn't get that done until after docking.

5.17 TRANSPOSITION

COLLINS Transposition and docking, in general, worked in flight just as it worked a couple of times in the simulator. I went MANUAL ATTITUDE PITCH to ACCEL COMMAND, and I started to pitch up. After 10 or 20 degrees of pitchup, when it was definitely established that the attitude error needle in pitch was full scale high (indicating that the DAP wished to continue the maneuver in the same direction in which I had started it), then I went PROCEED and MANUAL ATTITUDE

[redacted]

[redacted]

COLLINS (CONT'D) PITCH to RATE COMMAND. Then, just as in the simulator, the DAP rolled itself out. It ceased its pitch rate. I don't understand that. At the time, Buzz said that I had forgotten one PROCEED. As I recall, I went through this turnaround procedure exactly as the checklist was written. In the simulator, sometimes it worked like magic and other times it wouldn't. In flight, it worked just exactly like a bad simulator did. MIT or G&C people should check and see what if anything is wrong with this procedure. If I were going to fly this flight over again, I would say it doesn't matter if you pitch up or down. You ought to put those NOUN 22 values in there, hit PROCEED twice, and let the spacecraft turn itself around. You're going to get around within 30 or 45 seconds anyway. It's such a neat, simple, clean, easy procedure to do that way. The way we've got it designed, to make sure that we go pitchup instead of pitch-down, sort of mixes apples and oranges: Let the DAP do it, then you take control away from the DAP, then you give it back to the DAP; and, for reasons unknown to me, sometimes it works and sometimes it doesn't.

ARMSTRONG I'd say that the manual procedure is probably the best. That would be my preference.

[redacted]

[redacted]

COLLINS This is something that I'm sure Apollo 12 and other flights will want to massage. I'm firmly convinced that the way to save gas on that maneuver is to let the DAP do it. Make it a totally automatic DAP maneuver. The price you pay for that is that you never know whether it's going to pitch up or down. This is not important. In an effort to save gas and to assure that we always pitched up, I ended up wasting some gas.

5.18 STABILIZATION AND ALIGNMENT AT 50 FEET

COLLINS My procedure was worked out so I'd be 66 feet away from the booster at turnaround. Because of these delays and because of the fact that the DAP kept trying to stop its turnaround rate, I would say that we were about 100 feet away from the booster when I finally turned around. This cost extra gas in getting back to it. I don't know how much extra gas, they said 12 to 18 pounds over. I don't know how much they allocated. I think it was 60 or 70 pounds. That whole maneuver probably cost 80 pounds. In the simulator, doing it completed automated, I can probably do it for 30 to 35 pounds. The difference between 30 to 35 pounds and probably 80 pounds was just wasted gas.

[redacted]

[redacted]

5.19 DOCKING

COLLINS Docking, as in the simulator, was very easy. I did have a slight roll misalignment. I knew I had a slight roll misalignment, but everything else was lined up. Rather than diddle with it and make a last-minute correction, I just accepted it. It turned out later to be 2 degrees in the tunnel.

5.20 PHOTOGRAPHY DURING TRANSPOSITION AND DOCKING

ALDRIN We used the 16-mm camera. We used the settings that were listed in the checklist. We'll just have to look at how the film turned out before we can say too much more about that. I did use a fair amount of film and I think the pictures should come out reasonably well.

5.21 CSM HANDLING CHARACTERISTICS DURING DOCKING

COLLINS Absolutely normal. I docked in CMC, AUTO, narrow deadband with a 2-deg/sec rate. I went to CMC, FREE, at contact. Docking alignment was fine.

5.23 ADEQUACY OF SUNLIGHT

COLLINS More than adequate. There was plenty of sunlight. CSM docking lights were not required. The COAS reticle brightness, even with that filter removed, was still quite dim at

[redacted]

COLLINS (CONT'D) points during the docking. It is discernible if you really look closely. At the end when you need it, it's more visible than it is 20 to 30 feet out. I would say that the COAS is marginable, but satisfactory.

5.24 CABIN PURGE AND LM/CSM PRESSURE EQUALIZATION

COLLINS I believe all that went just about exactly as per the numbers.

ALDRIN We went PRESSURE EQUALIZATION valve to OPEN. Where it says go to A, we went to 3.8. That's where it stabilized. Repressure O_2 only brought it up to 4.4. That gave us a DELTA-P of near zero. There wasn't any cycling back and forth. There was just one cycle open and that's as far as it went.

COLLINS That cycling back and forth only applies if you have a problem when you don't have in the full volume of the LM.

5.25 CONFIGURING FOR LM EJECTION, DOCKING PROBE, VENTING LATCHES, UMBILICALS, POWER, AND TEMPERATURE

COLLINS Okay. The only funny here was when I opened the hatch to get into the tunnel, there was a peculiar odor in the tunnel. This odor was not exactly the same as burned electrical insulation.

ALDRIN You commented that the wiring in the cables seemed to retain this odor.

[redacted]

COLLINS I think that this is just normal. Fabric will retain an odor where metal will not.

ALDRIN I've noticed that same odor as characteristic of some of these new materials we have. A lot of the bags, when you get them right close to you, have this same burned-insulation odor. I'm not sure if that's it, but that might explain it.

COLLINS I don't know. My first impression was that something was burning or had been burned inside that tunnel. I went over every inch of wiring and all the connectors. I got a flashlight and looked at everything. It all looked absolutely normal. We chose not to discuss it with the ground because we hadn't popped any circuit breakers and everything looked normal. It seemed like evidence of a past problem rather than an existing one.

ALDRIN I think it would be a good idea for subsequent crews to sniff around and smell what this probe and umbilicals smell like beforehand.

COLLINS They don't smell anything like that. This was a sharp odor. I mean this was enough to knock you down when you opened the tunnel. It was one strong odor.

ALDRIN This stuff had been exposed to a vacuum.

[redacted]

[redacted]

COLLINS It had been exposed to the boost environment, too. I don't know how stuff would get under there with the BPC on. The BPC doesn't leave until you're darn near in a vacuum. Despite that, I thought that perhaps there was some odor associated with the high temperature of boost that had somehow gotten through the BPC and through that little tunnel vent line into the tunnel area. It sure smelled, and it smelled a couple of days later coming up on LOI. When I went in to activate the LM, the odor was just as strong.

All these latches made. Latch number 6, which is the one that had acted up a little bit down at the Cape during tests, was the only one that needed one actuation to cock rather than two. Other than 6, all the others said that they were going to require two pulls to cock and they did. All that hardware worked well.

We followed the checklist. We extracted in CMC, FREE, and then went to DAP control and fired the aft thrusters for 3 seconds. We went to CMC and DAP control 5 seconds after spring actuations. Neil and I both read a memo put out by MPAD, saying that for some failure modes you weren't supposed to do that; instead use SCS control. Ken Mattingly and I spent a lot of time the last couple of days before the flight

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[redacted]

COLLINS (CONT'D) trying to check all that out. It turned out to be sort of a witch hunt. For future flights, they might check into which is the best control mode for extracting the LM. I think it's okay the way we did it; but, if one of the springs gets hung up and throws you sideways, it may be better to do that maneuver under SCS control rather than CMC, FREE.

5.28 VEHICLE DYNAMICS OF CSM/LM DURING EJECTION FROM S-IVB

COLLINS There were no abnormal dynamics. The thing backed out absolutely symmetrically as far as I could tell.

5.29 ADEQUACY OF ATTITUDE CONTROL AND STABILITY

COLLINS The S-IVB was always very stable prior to, during, and after LM separation. SM RCS plumes had absolutely no effect on visibility or on S-IVB stability.

5.32 EVASIVE MANEUVERS

COLLINS We thought at one time we might be somewhat rushed during that time period. It turned out that was comfortable and we were prepared to do the evasive maneuver. We could have done it 5 or 10 minutes earlier than it was called for. Luckily, it is not a maneuver that is time-critical. I think the present scheme of causing the S-IVB to overburn by

[redacted]

[redacted]

COLLINS (CONT'D) 2 meters per second, and then intentionally burning the SPS for 3 seconds to compensate for that overburn appears to be a sound procedure. I recommend no changes to it.

ALDRIN I did notice the oxidizer unbalance to start out because it was bouncing around, but I have a note down here on the evasive maneuver that it changed from minus 180 to 130 decrease. That's only 3 seconds of burn, but you could see that this thing was in its decrease position all the time, which is what we expected. We just left it alone during that short burn. We got the first gimbal motor off a little bit before I was able to confirm it, so we had to go through a little rain dance of turning that back on and then back off again. That took a little extra time, and we used up a little extra amp-hours out of the batteries, but the ground did confirm it or at least try to confirm that we did get that gimbal motor off.

5.34 S-IVB SLINGSHOT MANEUVER

COLLINS Now, we never saw that. It seems like the attitude they gave us was not correct.

ALDRIN It was quite a while before we picked up the S-IVB, and it was rolling with a little bit of oscillation, a little coning effect. It definitely had a good roll to it moving away.

[redacted]

[redacted]

ALDRIN (CONT'D) This was during the nonpropulsive part of the vent and you could see two streams coming out of either side as the oxidizer was vented out. Exactly opposite to each other were two cones going out. I guess the cones were 30 degrees out one side and 30 degrees out the other, so it was definitely observable.

COLLINS But something appeared to be wrong with the attitude they gave us. I don't know whether they miscalculated or what, but they gave us an attitude to see the slingshot out the hatch window. We confirmed that we were looking through the correct window, and it wasn't there.

5.35 S-IVB VENTING OPERATION

COLLINS I don't know what to say about that. I guess it went normally.

5.36 PROPELLANT DUMP DURING SLINGSHOT MANEUVER

ALDRIN We didn't make use of that procedure of keeping — we didn't use it to any advantage of having the other state vector keep track of the S-IVB. It sounds Mickey Mouse, but it could have been some assistance in telling us where the S-IVB was.

ARMSTRONG Yes.

[redacted]

[redacted]

ALDRIN A range rate and a VERB 89. I don't know whether it's of any value; the other guys considered it anyway.

COLLINS I think that thing of watching the S-IVB is just the dealer's choice anyway. There's no need to watch the S-IVB. It's just that if you're going to go to all the trouble of getting the ground to compute three angles with which you should be able to see the S-IVB out a certain window, then you ought to get the correct angles.

5.37 EDS DEACTIVATION

COLLINS Nothing to say about that.

5.39 S-IVB CLOSEOUT

COLLINS I don't know what to say about that.

5.40 DOSIMETER

COLLINS In general, we got very little radiation. Of course, we were going through the Belts about this time. I don't recall that we looked at the radiation-survey meter. Did we do that? Did anybody look at that? I don't believe that was called out. We gave daily dosimeter readings, which as far as I'm concerned fall in a sort of a gee-whiz category. It's just information of very little value to anybody. They have other sources for it, and I suppose it goes on somebody's

[redacted]

[redacted]

COLLINS (CONT'D) graph somewhere for posterity. Other than that, I don't have anything to say about it.

ARMSTRONG It wasn't called out.

COLLINS And the dosimeter we just gave them a once-a-day reading on that dosimeter.

5.41 WORKLOAD AND TIMELINES

COLLINS Just in general, I thought all these workloads and timelines were quite reasonable and had been well worked out by previous crews and I'd recommend no changes to them. I thought that whole first 3 or 4 hours worth of activity was well thought out, and we were never rushed and we were never behind.

ALDRIN Well, our positioning of different people in different seats was a little unique, so it's a little different, I think, for other flights.

COLLINS Yes. Well, our seat position is a separate subject in itself. As far as being hurried, we were not, although the first 5 hours of the flight I thought were quite reasonable, and that's all I have to say.

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6.0 TRANSLUNAR COAST

6.1 IMU REALIGNMENT

COLLINS We realigned the IMU in Earth parking orbit. The next time we realigned it, we were, I guess, inertially fixed.

I remember now that our X-torquing angle was 0.172 degrees the first time, which seems excessive to me. We asked the ground to verify and they said it seemed excessive to them and to go ahead and redo it. So I went through P52 a second time. Instead of a minus 0.172 I got a minus 0.171. The results were repeated; therefore, the ground said go ahead and torque them, and we did. I don't understand why that torquing angle was that large. I guess it was an uncompensated X-drift, which they later compensated for more accurately, because the platform was well within its limits during the remainder of the flight. Yet this does seem like a large torquing angle.

Another general comment about the IMU was I couldn't get consistent star angle difference numbers. At various times in the flight, I got either 5 balls 0.01 or 0.02, and there was no correlation. As a matter of fact, there was negative correlation. The more time I took and the more precise I attempted to be, the more often I got 0.01.

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COLLINS (CONT'D) On a couple of marks, when I got 5 balls, I know that I was not precisely centered when I took the mark. So, I think that there was some small bias in the sextant.

6.2 DOFF PGA'S

COLLINS There were, as far as I can recall, no surprises in doffing the PGA's.

ARMSTRONG Buzz took his off first.

ALDRIN We were going to stow that from the back, and I was going to be the last one to put it on. Anyway, you were going to put yours on before I did.

ARMSTRONG As a result of a day that we spent in the CMS practicing taking the suits off and stowing them in the right place, in the right order, and so on, we decided to put all suits in the L-shaped bags: Mike's in the top, Buzz's suit in the bottom section to the rear towards the upward edge or the head end of the couch, and mine in the lower part of the L-shaped bag in the lower section. That worked fine.

All three suits did go in the L-shaped bag satisfactorily and could be stowed there. We left them out though for some period of time prior to stowing them to allow them to air out

[redacted]

ARMSTRONG (CONT'D) since they had been worn for a significant period of time prior to this. We wanted to try to dry them out before putting them in the bags for three days. That worked as planned, and we think that's a reasonable procedure.

ALDRIN Folding them, taking a little bit of care, seemed to pay off when you got to the point of wrestling with them to stuff them in, if you did it in a somewhat methodical way like putting one arm ring inside the helmet ring, and putting the other one in the chest. I actually took all the zippers off, then folded it over the gas connectors, and then ran both legs over and around and got it as tight as possible before putting it in. Well, it went in side-ways. It seems to fit into position quite well. No doubt about it; it was a bit of a wrestling match to do this and stuff it in. It just took a little bit of extra time and effort.

ARMSTRONG Maybe we're a little over protective, but I doubt that you could really damage those airlock connectors and helmet rings and so on. It was our intent to treat those with as much caution as we could, since we were really committed to their successful operation later.

[redacted]

6.3 OPTICS CALIBRATION

COLLINS Optics calibration worked all right.

6.4 PHOTOGRAPHY; EARTH AND MOON

COLLINS We didn't photograph the Moon at this time; the Earth we did.

6.5 SYSTEM ANOMALIES

ARMSTRONG At this time, I think, we were starting to home in on the O_2 flow discrepancies.

ALDRIN Yes.

ARMSTRONG I'm not sure we understand it completely. The gage was not, apparently, indicating the correct flow level and was varying with time. That's an indication for what we think might be a particular flow varying with time. It is evidenced by the fact that the quad accumulator cycle flow rate continued to decrease until it got down to about 0.3, and then it went back up to 0.4.

ALDRIN It would register around there each time. Then it seemed to go up almost to the safe value. That led me to believe that there was nothing wrong with our gage.

COLLINS Sounds like the gage was operable but out of calibration.

[redacted]

[redacted]

ALDRIN Right.

COLLINS We spent a lot of time with EECOM before the flight discussing what items to check and what items not to check. I suppose as long as we have space flights, we're going to have philosophical disagreements on how exhaustively we want to check all the equipment. My personal philosophy is that if you don't have some reason to believe that it's broken, leave it alone. Don't fool around with it. FOD, of course, has a number of mission rules that require verification of each and every component of each and every system to make sure that they're not going to violate one of the mission rules. I can understand their viewpoint. Maybe the truth lies somewhere in the middle. We ended up after many, many discussions including the operation to make sure that the glycol was flowing satisfactorily through the secondary radiators without any leaks and to make sure that the secondary water boiler was functioning properly. We did that pre-TLI. Then pre-LOI, we checked only for gross radiator leaks and did not check secondary water boiler operation.

ALDRIN It wasn't really a difficult time-consuming task. It went very smoothly.

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[redacted]

COLLINS It's a question of whether you want to do it. For example, on the secondary glycol radiator leak check, the secondary glycol loop has been bypassed, that is, no fluid has been allowed to go through the radiator. You put the valve from bypass to flow for 30 seconds, turn the pump on, and allow fluid to flow through the radiator. Then you confirm that there is no leak by checking the accumulator quantity and making sure that it does not decrease. So what happened? In this case, accumulator quantity decreased by about 4 percent. This had never come up before. The ground suspected that it was due to thermal characteristics in contractions or expansions in the system, and not a leak. It dropped and then stabilized. I preferred to leave that equipment alone rather than mess with it.

I guess there was no leak. On the other hand, we could have gotten into a big argument over a suspected leak even to the point where you might have to delay TLI by a revolution. If you don't have concrete evidence that something has malfunctioned, and it's your backup system, leave it alone. Don't mess with it.

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6.7 CHLORINATE POTABLE WATER

ARMSTRONG We did this once a day before bedtime. The little injector assembly got more and more difficult to operate as each day went by. The chlorine tends to stick and corrode the screw threads. What started out to be a fairly low torque application, towards the eighth day got to be a fairly difficult task to screw the container down so that the chlorine capsule in it would get squashed. We also got some leakage the first day due to the fact that I did not have the threads fully engaged. It felt to me as if I did have the threads engaged. However, when I started screwing it down, I found I didn't. Chlorine was escaping, and I had to get the towel out and mop it up. After that, I didn't have any trouble with it.

ALDRIN I found myself invariably wanting a drink of water after we chlorinated the water. You couldn't do that unless you put some in the bag ahead of time. We should have done that. It just didn't occur to us until afterward.

COLLINS I certainly don't think it's worth changing the system for mainline Apollo. For future spacecraft, you'd certainly like some built-in way of assuring yourself of a germ-free water supply without having to go through this kind of procedure.

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[redacted]

6.8 COMMUNICATION SETUP FOR REST PERIOD

ALDRIN The way that the flight plan handled it was a little involved. We were in a translunar switch setup. It would say each time for rest period go to lunar coast except for such and such. In the LM, we had a fairly simple way of handling it. We just labeled, straight on down the line, the position of the switches. We could probably come up with something similar to this. It could include just a certain set number of switches that are all S-band. You just make a quick check of all these and have them in the right configuration, instead of having to refer back to the systems management book. Keep that checklist out of the flight plan, and keep it in the checklist.

ARMSTRONG The checklist is pretty long, so you end up with a fairly complex piece in the flight plan and also a complex list in the systems book.

ALDRIN But the flight plan does have two sleep mode options: high gain or OMNI. So, you really have more than you need in the flight plan.

ARMSTRONG We insist that we only go in the ONMI mode during sleep periods. We decided that it would be best.

[redacted]

6.10 EASE OF OPERATIONS OF COMMUNICATIONS

COLLINS They were all right. There were also times when we had communications dropout that I don't think were explained. I had the feeling that there were a lot of ground antenna switching problems. There would be times when we really should have had sound and we didn't. It was due to some sort of a ground problem. It seemed to me that there were a lot more of those problems on this flight than there were on Apollo 8.

ARMSTRONG You probably noticed that in the Center, too, handovers and switching.

ALDRIN We chose not to control it on board, switching from one OMNI to the other. We let the ground handle the whole thing, and they just have a choice between two OMNI's. They are going to run into some dropouts invariably.

COLLINS The PTC rate we used was 0.3 deg/sec. For the crew to switch OMNI's manually and go around A, B, C, D during the time when they're awake is really too much of a job, because you're having to switch OMNI's approximately every 5 minutes.

ALDRIN It's 18 minutes.

[redacted]

COLLINS So, I think it's a correct decision to let the ground switch between opposites B and D OMNI antenna rather than having us switch manually A, B, C, D; but I guess the ground needs some refinement in that procedure because we did have a number of cases of COMM dropouts, and later on in lunar orbit, it was even more so.

6.12 PREFERRED PTC MODE AND TECHNIQUE FOR INITIATION

COLLINS There are all sorts of real varied funnies in the checklist (page L9-6) for how to get into PTC. Now, just for example, during the period when you are waiting for the thruster firing activity to quiet down, there's a 20-minute nominal wait period for thruster firing to diminish. And for instance, if the crew wants to see how the thruster firing activity is coming along, the way of verification is VERB 16 NOUN 20, monitoring the gimbal angle, and watching the lack of change in the gimbal angles. Yet, if you do that and leave VERB 16 NOUN 20 displayed on the DSKY, when you proceed 8 or 10 steps later to the point where you start to spin the spacecraft up, instead of getting 0.3 deg/sec rate, you will get a rate in excess of 1 deg/sec. And this fact is not well known. This is something that we found in the simulator shortly before the flight and penciled into the checklist.

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COLLINS (CONT'D) But I would just say in general that that checklist should be reworked. There are many little pitfalls. For example, if you find yourself in an inertial attitude, and all you want to do is spin up around that attitude, the checklist implies that you can just go into it at that intermediate point, but that is not the case either. You must pretend that you are in the wrong attitude, ask the computer to maneuver you to the right attitude and then go through the entire checklist from that viewpoint, or it won't work properly. These are just two pitfalls that I happen to know about right now.

ARMSTRONG It seems to me that the point is that this is a very good procedure that worked extremely well, and we're going to find that it's extremely easy to use but has not stood the test of time yet. It needs a lot more experience in use before we could use it reliably and repeatedly every time without causing a later problem that we couldn't predict.

COLLINS That's right. Another little facet of it is that after the PTC is initiated, then there are certain no-no's in regard to the use of the DSKY's having to do with collapsing deadband and other problems internal to the computer.

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COLLINS (CONT'D) So, I think some explanation and expansion in those pages in the checklist is in order.

ARMSTRONG It's probably worth noting here, while we're thinking about it, there seems to be some advantage to writing a program to do this job. At least it should be considered, rather than the one we're using at the present time. It could obviate many kinds of minor difficulties that we didn't mention until now.

6.14 EASE OF HANDLING OPTICS AND SPACECRAFT FOR NAVIGATIONAL SIGHTINGS

COLLINS With P23, as I practiced it in the simulator and made use of the AUTO optics to maneuver the spacecraft to each star substellar point, the flaw in this technique is that the spacecraft roll angle is unconstrained in that with large trunnion angles, the computer may pick a roll attitude which causes the star to be occulted by the LM structure. Now, the flight planners came to me a couple of weeks before the flight and said that to get around this disadvantage of the AUTO optics, they wanted to use ground-computed angles to which to maneuver, and then these ground-computed angles would have a roll angle which would assure that the star would not be occulted by the LM structure. And at that time, I told them that all my

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COLLINS (CONT'D) training had been built toward using AUTO optics for these maneuvers. I asked them to go back and find stars whose trunnion angles were small enough that this would not then be a problem (the LM structure occulting it). Flight planning talked to the MPAD people and said that they could not find such stars with the proper in plane/out of plane geometry. But the ground-computed angles would locate satisfactory substellar points and all subsequent maneuvers would be very small. Now, I should have called a halt right there and sat down with the flight planning people and with the MPAD people, and I should have gone through each star, each maneuver, each gimbal angle, each subsequent substellar point, and ironed out just exactly step by step how many maneuvers would be required; the size of them and exactly what was being furnished to me in regard to roll angles. However, I didn't. That's one of the things that fell through the crack. So, in flight when I maneuvered to the ground-supplied angles, I found that I was nowhere near the substellar point as determined by the fact that the sextant reticle was not parallel to the horizon at that point. And here I think we had some kind of a communications breakdown with the ground, because I kept telling them that this was not at a satisfactory substellar point, that the reticle was not parallel

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COLLINS (CONT'D) to the horizon. They kept telling me that it was all right to go ahead and mark anyway.

ALDRIN They didn't really mean that. We're sure they didn't.

COLLINS Now, I'm not sure what they meant. Maybe you hit the nail on the head. What they meant was that the spacecraft did not have to be rolled in such a manner that the spacecraft roll was parallel to the substellar point. In other words, what they were saying is that the computer program could accommodate a change in spacecraft roll simply by torquing the optics around to go off at a peculiar angle. Nonetheless, when you look through the sextant to get accurate marks, you must have the reticle pattern parallel to the horizon or you are not measuring the true angle between the star and horizon. Here's the star and the horizon, and instead of measuring this angle, you're measuring this angle or that angle or some other oblique angle that is larger than the true angle, which is the angle from the star normal to the horizon. So this initial run on P23 got very confused. The following day, the problem went away because we were far enough away from the Earth, and the fact that their angles were not at the substellar point became immaterial because the Earth was small enough that a very small maneuver on my part could locate the

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COLLINS (CONT'D) substellar point. But when you are close to the Earth, and the Earth is very large, and you have an obvious roll on its alignment in the reticle, then it requires a very large maneuver to maneuver the spacecraft over to the substellar point. I'd be happy to draw it on a blackboard some other time for the proper people. I was reluctant to make these large maneuvers, because I thought something was wrong. And they kept saying go ahead and mark, that it was all right, and so I did take some marks and the DELTA-R's and the DELTA-V's were excessive. I don't know what else to say now. I'd sort of like to get a blackboard and talk this over with flight planning and with the people from MPAD, if necessary, and see where we went wrong. It's my fault in that I didn't get all the interested parties and sit down and go through step by step and maneuver by maneuver exactly where we were going to go and what we were going to do.

ALDRIN I think it's one of these areas that it would have been nice maybe, for you anyway, to have had an abbreviated simulation with Houston as part of our training. One big problem there is that you just can't always count on the simulator giving enough fidelity.

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ARMSTRONG Yes. I think that's one of the areas where the simulator probably falls a little short.

COLLINS In my mind, it's a question of time available. I had so much stuff to learn, and I had divided up the time, and P23 was a relatively small slice of the overall training. I didn't want to really spend the time to sit down and go and hammer this stuff all the way through, although it appears I should have. That's another thing. That state vector was another heartache.

ARMSTRONG The state vector may have been bad initially but especially when you get two large errors in a row. We incorporated it, and from that point on, the state vector wasn't any good.

COLLINS That's right. The state vector was mediocre to begin with and it rapidly got worse.

But each star has its own distinct substellar point, and you take a measurement on two stars in a row. This requires that you maneuver from one substellar point to another. I kept telling those people that before the flight and they kept saying, "Oh no. They're all right close together." I think there's some confusion on their part and maybe some on mine.

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ALDRIN I think it's all unfortunate that the first mark, the first star set that we had, was changed in the flight plan.

COLLINS Well, that's another thing. We didn't mark correctly. Sometime between the last time we simulated it and the first time we pulled this out in the flight, star number 2 had been moved from the number 1 position down to number 4 position, and they had done it just by changing the 1 to a 4 and drawing a little arrow. When you read me the numbers, you didn't note that I read star number 2 and it was the same old star I had always marked on first. That was just a bad area. A little bit of work could have cleaned that up before the flight, and I just didn't have the time or the inclination to sit down and hammer it out with the people required, and I should have.

Well, we were fine the next day only because the Earth was so much smaller. If you have a little Earth and you're supposed to be marking on this point and you're at this point, it's no big deal to move from here over to here. But the Earth is big and you're supposed to be marking on this point, and you're really over there; that requires a big maneuver. The same problem existed the next day. However, a tiny maneuver on my part solved

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COLLINS (CONT'D) the problem; whereas the day before it was a huge maneuver, and I was reluctant to make that maneuver.

As a general comment, I've found that the telescope was a very poor optical instrument in that it required long, long periods of dark adaptation before any star patterns were visible. In most cases, it was not convenient to stop and spend the amount of time necessary to make any use of the telescope. Thus, we kept our platform powered up continually. My procedure was to ignore the telescope and to take at face value what the sextant said. In other words, if the sextant AUTO optics came up with a star in the sextant field of view, I accepted it as a matter of fact that it was the correct star. We marked on that star without any further verification. I suppose this could rise up and bite you, but I felt safe and comfortable with it, and it worked throughout the flight.

6.15 ADEQUACY OF PROCEDURES TO PREPARE FOR AND ACCOMPLISH THE TRANSLUNAR MIDCOURSE CORRECTIONS

COLLINS Now by that I assume they mean the ground-supplied sequence, and that I felt was fine. Got any comment about that?

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ARMSTRONG Well, they may also be referring to P30 and P40 sequence and so on. And it was our intention to do those very carefully in just the way that they are detailed in the procedures; not because the burn was all that important and we compensated for it if we made an error, but rather because the analysis of that burn on the ground was going to be the thing that determined that we have a good SPS for LOI. Because that was the case, we wanted the ground not to be at all confused about what procedures we would use and just how the burn was made. So we tried to stick precisely with the same procedures you'd use for an SPS burn.

COLLINS In general, I thought all the P30's and P40's worked out very smoothly.

6.16 MIDCOURSE CORRECTION

ARMSTRONG Well, the first midcourse was cancelled to allow the DELTA-V value to grow in size so that the second midcourse correction would be reasonably longer, allowing engine operation to be well stabilized and more accurately analyzed on the ground.

ALDRIN Midcourse 2 was 21.3 feet per second.

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ARMSTRONG The results of that were very, very good and the residuals were very small, 0.30 and 0.20. But there was some question about the fact we had a relatively large EMS residual; namely, 3.8 ft/sec in about a 20-ft/sec burn. The predicted knowledge of tail-offs apparently was badly in error or else the knowledge of the EMS itself in the tail-off region was badly in error. That never was corrected throughout the flight. We saw this condition through the rest of the SPS burns.

ALDRIN Did it say anything about the sextant star check? They updated that. It was pretty much out of sequence.

ARMSTRONG The first one they gave us. Then the second one was in that direction because, of course, the LM was there.

COLLINS It was our desire that insofar as possible an inertial attitude check be made (in the absence of the burn) so that if you made the burn they knew you were in fact pointing in the right inertial direction. Of course, the LM is out in front of you and you can't look down the X-axis of the optics, so you're constrained not to point any closer to the X-axis than the LM will allow. However, the initial values that they gave us were sort of like down the Z-axis. Of course, you could have the

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COLLINS (CONT'D) optics pointing down the Z-axis and then you could be free to pass that test and still have the spacecraft pointing 180 degrees out from where you want it to be. It will still pass that test, so in our view that wasn't particularly good. You were really just checking your alignment of the platform, which is really not what you're trying to do. You're trying to check that the spacecraft is pointed the way you want it pointed so that was the reason for our request for additional star checks.

6.17 ADEQUACY OF CSM/MSFN COMM PERFORMANCE AND PROCEDURES FOR COAST DURING AGA REFLECTIVITY TEST

COLLINS Okay. Adequacy of all this stuff for the AGA reflectivity test. I understand we didn't have that and we cancelled that.

6.18 TELEVISION PREPARATION AND OPERATION

COLLINS I thought in general the onboard color television system was well designed and was easy to operate. Buzz, you got anything to say about that?

ALDRIN It was quite easy to hook up and put together. We ended up putting the two together making use of tape instead of the Velcro that was on there, to get the monitor right close to the camera. I think initially we were a little

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ALDRIN (CONT'D) tangled up in wires. There were wires all over the place, and we were running around from one strut to the other. We found out that it was set to have the monitor attached right to the camera itself, so from that point on, we taped the monitor beside the camera.

ARMSTRONG Well, we have a couple of comments we'll get into sometime later with respect to television, but with respect to its operation, it's unquestionably a magnificent little piece of equipment. However, you cannot operate it without any planning at all. You do have to think about whether the vehicle is rotating or not, in what area you're going to take pictures, where the lighting is going to be from, and through what windows, and all that sort of thing. This takes some planning to enable you to assure yourself that you are going to get a good TV picture of whatever you decided you are going to take a picture of.

COLLINS That's right, and the monkey is on the back of the crew, functioning as script writer, producer, and actor, for the daily television shows. We had no time nor inclination preflight to plan these things out so they were all sort of spur-of-the-moment shows. And maybe that's a good way to do business and maybe that's not. I don't know. Maybe other flights with perhaps more time to devote

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to this should give some thought to what has previously been done and what are the best things to cover and when is the best time to present them. The next crew should spend a simulator session working out things like angles and light and what have you.

ALDRIN There is no doubt that you want to do it right, because there's a big audience looking on.

ARMSTRONG It inspires you a little bit when all of a sudden you have about 10 minutes left to go for a scheduled TV broadcast and the ground says there are 200 million people waiting to see you. They're all watching. Now what are you going to be showing?

COLLINS We're trying to paint the picture of having this highly trained professional crew performing like amateurs. They don't know where to place the camera or what to do or what to say. It hasn't been well worked out. I feel uncomfortable about this.

ARMSTRONG It's just fortunate that the camera is as good as it is and it compensates for the inabilities of the operators.

ALDRIN I think that some of the better things that we did were just monitoring and just trying things out before we got to the point of putting on the show. I think there is

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ALDRIN (CONT'D)

the ability of people on the ground to see what's coming across, look at it, select what they want, and then assemble it together and release it. I'm sure everyone wants to have a real-time picture and voice along with it, but you're going to suffer somewhat in the quality you get. For example, activity in the LM, when we were just trying to see how it was working. All of a sudden we found that we were going out live and we were completely happy with that. This was one of the better shows we did.

ARMSTRONG

I agree with that, but on the other hand there is another side to that discussion that doesn't involve somebody thinking about how that situation can be handled. We can put out something that the agency is willing to stand behind and can be proud of without the crew having to make a lot of last-minute quick guesses as to what they ought to be doing.

6.19 HIGH GAIN ANTENNA PERFORMANCE

COLLINS

It was okay, I guess.

ALDRIN

It seemed to work fine. I placed it in AUTO, threw the switch over to MEDIUM or NARROW, and just a couple of seconds later the signals transferred.

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ARMSTRONG There was one observation here that seemed to me to be different from the simulator. In the spacecraft, I could seldom if ever detect a difference in signal strength between MEDIUM and NARROW. In the simulator, it's always decidedly different. The conclusion to be reached is that either the simulator is not an accurate representation of signal strength or that we really weren't getting any difference between MEDIUM and NARROW beam. We were, in fact, stuck in one or the other irrespective of switching.

ALDRIN I would expect there wasn't as much difference between WIDE and MEDIUM, but when you went to the NARROW, you could see it. It wasn't consistent. In any case, it was unlike what we were used to and as long as the signal was received, I guess it's not a problem.

COLLINS I think that's a function of distance, too. Now in lunar orbit, there was a noticeable difference between MEDIUM and NARROW. But there were some funnies in that high gain antenna. We were playing with it some time and we didn't have control over it and the ground had one of the OMNI's selected. We thought we were controlling it and we

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COLLINS (CONT'D) weren't. Another funny was that there were ground-switching problems where the thing was not receiving a proper signal.

ALDRIN I remember one time the ground said go ahead and turn the high gain off. I complied and we lost COMM. I don't think they expected it; the next time they had control, we were on OMNI at that time. It wasn't at all clear to me at all times who had control and who was running the show.

COLLINS That's right and it was a great temptation to go to command reset to make sure that we had control, except that that threw six or eight other switches that we were reluctant to change. I suspected at times that it was not working properly. I never absolutely caught it malfunctioning. I think those suspicions mostly had to do with the fact that we didn't have control of it or the ground had some sort of a sighting problem.

ARMSTRONG The confusion in my mind often was that I wasn't really sure what our configuration actually was. You can't tell by the switches and trying to interpret what you see in terms of the displays you have available and what you hear

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ARMSTRONG (CONT'D) through your earphone doesn't always lead you to the right conclusion and that's a little bit disconcerting.

6.21 S-BAND SQUELCH

ARMSTRONG It worked very well, I thought.

6.22 DAYLIGHT IMU REALIGN AND STAR CHECK

ARMSTRONG I think we already covered that by saying that with the LM on in the daylight the telescope is nearly useless and you have to rely on the sextant. Now, we never went into that mode that Apollo 10 discovered of pointing the plus X axis at the sun. We never had an occasion or need to do that. Therefore, we can't comment on it. Just staying regular PTC attitude, normal to the sunline, the telescope was just about useless.

6.23 VENTING BATTERIES AND WASTE

ALDRIN When we started a battery charge, we would look at the vent and find it was usually down fairly low. I don't think there was any time when we saw it above 1.6 and as soon as we went to VENT, it would drop down to 0.2 or 0.3. I don't know how serious that is. Nobody seemed to be concerned about that. I'm sure that the ground has a readout, but they never indicated or suggested to us that we vent the batteries.

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6.24 RADIATORS

COLLINS We never flowed through the secondary radiators because the primary worked fine. The cabin temperature (translunar) was slightly warmer than we would like it, although the gage readings were quite cool. We were running 60 degrees cabin temperature and 57 degrees suit temperature.

ARMSTRONG High 40's in the suit and low 60's in the cabin.

COLLINS Yet we were warm in spite of those low numbers.

6.25 CM/LM DELTA PRESSURE

COLLINS Well, the LM pressure would slowly decay, but remain well within tolerance. I don't have any good numbers. It was a tight LM.

6.26 RE-ESTABLISHING PTC

COLLINS We've already discussed that, I think. We always used 0.3 deg/sec roll and we never tried the 0.1. It would be advantageous, in regard to antenna switching if stability is satisfactory, and 0.1 deg/sec would probably be a better mode than 0.3. It would also save some gas. However, we did not investigate that. Perhaps that ought to be something for future flights to look into. I think that theory has been mentioned to FOD.

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ALDRIN Maybe.

6.27 HIGH GAIN ANTENNA PTC REACQ CHECK

COLLINS We did it coming back.

ALDRIN When it worked, it worked like a charm. There were a couple of times when it didn't seem to want to work.

6.28 OPTICS CALIBRATION

COLLINS Optics CAL the next day worked fine.

6.29 FUEL CELL PERFORMANCE AND PURGING

COLLINS The fuel cells performed perfectly. Purging didn't present any problems. We followed the checklist on the heaters and they worked normally.

6.30 LM AND TUNNEL PRESSURE

COLLINS LM and tunnel pressures were normal.

6.31 LATCH VERIFICATION

COLLINS Latches, as I say, were all verified. Latch number 6 required one actuation to cock. That was the only anomaly and it was within the realm of normal.

6.32 INSPECTION OF TUNNEL MECHANICS

COLLINS I'm not sure what that means, but everything in the tunnel was normal.

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6.33 REMOVAL OF PROBE AND DROGUE

COLLINS Probe and drogue removal was absolutely normal. Have you anything to say about that?

6.34 IVT TO LM

ALDRIN Well, as far as I'm concerned there was no disorientation in going from one spacecraft to another. It was quite easy to go from one to the other. It would take a little readjusting to get yourself into position when you first entered one vehicle or the other. You weren't sure what you were looking at. But there was no disorientation associated with that.

ARMSTRONG I didn't observe any problems with that.

6.35 16-MM CAMERA

ALDRIN We may not get back to this again, but I think that the exercise we had in the LM was extremely valuable from our standpoint. It was conducted from a very comfortable timeline. We had no particular schedule to meet; we used the camera to document. In addition, the television set at this time was quite valuable.

6.37 IVT TO CM

COLLINS From the CMP position, it was of great value to have a one-day head start on the removal of the probe and the

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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.

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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.

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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.

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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.

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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.

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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.

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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

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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.

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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.

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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

[redacted]

[redacted]

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

[redacted]

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

[redacted]

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

[redacted]

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.

[redacted]

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 ...

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

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

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

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

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

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

[redacted]

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

[redacted]

[redacted]

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

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[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

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.

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

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.

[redacted]

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

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

[redacted]

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

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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

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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

[redacted]

[redacted]

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

[redacted]

[redacted]

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.

[redacted]

[redacted]

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.

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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

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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

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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

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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

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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

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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

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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

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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

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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

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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.

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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

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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,

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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

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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

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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.

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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

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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

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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.

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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.

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10.0 LUNAR SURFACE

ARMSTRONG The postplanning checklist went as planned, and venting was initiated in the OX tank almost immediately — even before the point on the timeline called for it.

We ran the OX pressure down to the 40- to 50-psi range and opened the fuel vent and vented it down the same amount. We then closed it off after which time Houston became concerned with tank pressures and asked us to reopen it again, although at the time we were reading relatively low tank pressures. I think the OX built up slightly over 50 at the time, but they were apparently reading a higher value, and I assume perhaps that they had an error in their signal from that tank pressure. In any case, we opened both tanks after that and let them bleed down to about <u>15 psi</u>, which was probably the stable condition of the vapor pressure in the tank at that point.

ALDRIN After touchdown, we got a GO for T-1 and then we proceeded to enter P68 and recorded the latitude and longitude and altitude. We then proceeded out of that and reset the stopbutton and entered P12 for T-2. At this point, I think that a little shuffling in the data

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ALDRIN (CONT'D) cards might prevent someone from making the same error that I did in loading the tape for ascent. On the data card, we've got the PDI pad, which is referred to somewhat during descent. It has PDI aborts on it with a NO PDI plus 12 abort on the right side. I think that the NO PDI plus 12 abort would be better placed on the back of this altitude card because, once you ignite, you're through with that NO PDI plus 12 abort and you ought to get it out of there. In its place, I think the T-2 abort pad should be on the data card because when I started to load P12 with NOUN 33 (the TIG for this T-2 abort, which is PDI plus 23), I loaded the TIG for the NO PDI plus 12 abort, and the ground caught me on it and said, "You loaded R-2 wrong." Instead of loading 10254 29, I loaded 10244 27. Now, the two are pretty close and they both say TIG NOUN 33. So, I think if we can get that one abort (NO PDI plus 12 abort) out of there and put the other one in its place, it'll save someone from coming up with the same sort of thing.

We got remote control back to ATTITUDE HOLD and AGS, OFF and then cycled the Parker valves again. After having seen the erroneous talkback indications, I was expecting

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ALDRIN (CONT'D) that when I put the feeds to close they would indicate open momentarily. The crossfeed was cycled again to close. I turned the camera off and proceeded with the switch configuration. Cycling the CWEA circuit breaker did, in fact, turn off the descent Reg warning lights. We read the sine and cosine out of AGS (and I'm sure they copied that down) and went immediately into recording the AGS gyro coefficients. I'm sure that these were the same numbers that we finished up with, but it might be a good time to check. Then we went to cabin on the regulators and took our helmets and gloves off. Then we started in with the initial gravity alignment. I don't have the first NOUN 04 that we got. I didn't record that one, but it was fairly large. I've seen so many of them in simulation that I just can't recall what that number was.

ARMSTRONG I am sure that it was recorded on the ground.

ALDRIN After the recycle, it was 00001. We asked them about recycling and they said affirmative. Got a star-angle difference of 00015 and some torquing angles, which showed a fairly good change. I guess the pitch is the

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ALDRIN (CONT'D) one you're concerned with. That's about the Y-axis; that was 0.1. I don't know whether the sine of that agrees at all with the approximation of 0.1 that we got in the Sun check. We didn't torque those angles. The ideal was to get a gravity direction and then to do a two-star alignment and look at the torquing angles after the two-star check which would then give an indication as to what the drift had been since the last alignment. The initial gravity alignment, combined with the two-star alignment, would produce a new location of the landing site. Had we landed straight ahead, my intent was to use Rigel in the left detent number 6 and Capella in the right detent. The 13-degree yaw moved Capella out of the right-rear detent, but Rigel was in good shape there. That's the one I used first. I then selected Navi in number 4 detent, the right rear, and that wasn't particularly satisfactory. It was quite dim and it took a good bit longer than I had hoped to get the marks on that. I can't comment particularly on the star-angle difference other than it was a little disappointing in that it was 00009. Torquing angles we have recorded, and we did torque. The latitude and longitude — we'd have to listen to the guidance people as to just what

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ALDRIN (CONT'D) that did to our possible touchdown point. It seemed to me, when we finished that, we were just about on schedule, maybe a little bit behind so we proceeded into the option 3 which was gravity plus one star; because Rigel had been so good, I used that one again. The gravity alignment seemed to be quite consistent. The first time we did the gravity alignment on option 3, it came up with 00000, our star-angle difference on the gravity plus one star, which indicates an error in that gravity measurement and star measurement was 00008. I know we had the torquing angle recorded on that also. The azimuth is very large — 0.2 degrees. We received a GO for T-3. In the vicinity of loading times for a T-2 abort, I noticed that the mission timer wasn't working. It was frozen; it just stopped.

ARMSTRONG No, it didn't just stop.

ALDRIN Yes, it had gone to 900 hours.

ARMSTRONG 900 and some hours. I couldn't correlate the minutes and the seconds with any particular previous event.

ALDRIN Yes. 903:34:47. I don't know what time that relates to. Obviously, the 9 digit changed. It might have stopped,

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ALDRIN (CONT'D) but it was static at that point. We ran through the circuit breakers but couldn't seem to get it moving again. The ground suggested that we turn it off which we did, but when we turned it back on we got all nines. You could change the last digit with the digit sequencer. We turned it off for a while and turned it back on again and it worked after that. We gave them an E memory dump; got a new ascent pad or the CSI pad, for T-3. We then proceeded on with the option 3 alignment. Continuing through the checklist, looking at switch settings, and circuit breaker cards, we found ourselves 10 minutes to go and essentially up on the checklist. At that point, we had to start pressurizing the APS if we were going to launch, so we read through the remainder of the simulated countdown and decided that there wasn't any point in sticking with that timeline any further. So we terminated the simulated countdown and went to the initial powerdown sequence. We had discussed among ourselves the possibility of evaluating, during this first 2 hours, whether we wanted to go on with the rest period that was scheduled or to proceed with the EVA preparation. I think we had concluded before the end of the simulated powerdown that we would like to go ahead

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ALDRIN (CONT'D) with the EVA and it was sometime in here that Neil called to ground and let them know that.

ARMSTRONG There were two factors that we thought might influence that decision. One was the spacecraft systems and any abnormalities that we might have that we'd want to work on, and the second was our adaptation to 1/6g and whether we thought more time in 1/6g before starting the EVA would be advantageous or disadvantageous at that point. Basically, my personal feeling was that the adaptation to 1/6g was very rapid and was very pleasant, easy to work in, and I thought at the time that we were ready to go right ahead into the surface work and recommended that.

ALDRIN Now, we estimated EVA at 8 o'clock. I think that was a little optimistic. The ground recognized that, because they said, "Do you mean beginning of PREP or beginning hatch opening?" And all during this time, we could tell that Mike was kept busy each pass, doing P22's trying to find where we were.

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10.8 HORIZON, SIGHTING, APPEARANCE

ARMSTRONG The things that seem worthy of comment here are observations from the window prior to lunar surface work. We were in a relatively smooth area covered with craters varying from up to perhaps 100 feet in the near vicinity down to less than a foot, with density inversely proportional to the size of the crater. The smaller they were, the more there were of them. The ground mass was very fine silt, and there were a lot of rocks of all sizes, angularities, and types in the area. Our immediate area was relatively free of large rocks. Several hundred feet to our right there was a significant boulder field, an array of boulders, essentially, that had many boulders greater than 1 or 2 feet in size. We never were able to get into that area to look at those rocks in detail.

ALDRIN Distances are deceiving. When we looked at this fairly large boulder field off to the right, it didn't look very far away at all before we went out. Of course, once we got out, we wandered as far as seemed appropriate. Of course, we never came close to this particular field. What really impressed me was the difference in distances. After we were back in again looking out at the flag, the

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ALDRIN (CONT'D) television, and the experiments, they looked as though they were right outside the window. In fact, on the surface, we had moved them a reasonable distance away.

So I think distance judgment is not too good on first setting down. The tendency is to think that things are a good bit closer than they actually are. This says they are probably a good bit larger than what we might have initially estimated.

10.10 COLORS AND SHADING OF LUNAR SURFACE FEATURES

ARMSTRONG Probably the most surprising thing to me, even though I guess we suspected a certain amount of this, was the light and color observations of the surface. The down-Sun area was extremely bright. It appeared to be a light tan in color, and you could see into the washout region reasonably well. Detail was obscured somewhat by the washout, but not badly. As you proceeded back toward cross-Sun, brightness diminished, and the color started to fade, and it began to be more gray. As we looked back as far as we could from the LM windows, the color on the surface was actually a darker gray. I'd say not completely without color, but most of the tan

ARMSTRONG (CONT'D) had disappeared as we got back into that area, and we were looking at relatively dark gray. In the shadow, it was very dark. We could see into the shadows, but it was difficult.

ALDRIN We could see very small gradations in color that were the result of very small topographical changes.

ARMSTRONG Of course, when we actually looked at the material, particularly the silt, up close it did, in fact, turn out to be sort of charcoal gray or the color of a graded lead pencil. When you're actually faced with trying to interpret this kind of color and that light reflectivity, it is amazing.

ALDRIN When illuminated, it did have a gray appearance, very light gray.

ARMSTRONG Wouldn't you say it is something like the color of that wall? It isn't very far away from what it looked like. Yet when you look at it close, it's a very peculiar phenomenon.

10.15 PREPARATION FOR EGRESS

ARMSTRONG Now, a preliminary comment has to do with the longer time that it took than during our simulations. It is

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ARMSTRONG (CONT'D)

attributable to the fact that when you do simulations of EVA PREP you have a clean cockpit and you have all the things that you're going to use there in the cockpit with you and nothing else. In reality, you have a lot of checklists, data, food packages, stowage places filled with odds and ends, binoculars, stop watches, and assorted things, each of which you feel obliged to evaluate as to whether its stowage position is satisfactory for EVA and whether you might want to change anything from the preflight plans. For example, our mission timer was out, and we decided we had better leave one wristwatch inside in case it got damaged. We would have at least one working watch to back up the mission timer or to use in place of the mission timer, in case we could not get it going again.

All these items took a little bit of time, a little bit of discussion, which never showed up in any of our EVA PREP's on the ground, really accounted for the better part of an hour of additional time. Our view of EVA PREP was that we were not trying to meet a time schedule. We were just trying to do each item and do it right sequentially and not worry about the time. Well, the

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[redacted]

ARMSTRONG (CONT'D) result was, a lot of additional time used there. I don't think that's wrong. I just think in future planning you are probably better off adding time for these kinds of things.

ALDRIN No matter how many times you run through an EVA PREP, to the best of the instructor's ability to put things in a logical sequence, when you're faced with doing these things, there is a natural tendency to deviate somewhat from the printed sequence that you have. It's a rather complex operation. Nobody writes a checklist to tell you in the morning when you get up all the sequences you go through to put your clothes on, brush your teeth, shave, and all that. If you had one setting there, you wouldn't follow it the same every day. You would make small deviations just based upon what seems appropriate at that time. It is a very difficult thing to build a checklist for.

ARMSTRONG We shouldn't imply that the EVA preparation checklist wasn't good and adequate. We did, in fact, follow it pretty much to the letter just the way we had done during training exercises. That is, the hook ups, and where we put the equipment, and the checks were done

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ARMSTRONG (CONT'D) precisely as per our checklist. And it was very good. I don't have any complaints about that at all. It's these other little things that you don't think about and didn't consider that took more time than we thought.

There was one control on the PLSS that surprised us. I don't know if it was different from the trainers or the flight PLSS's at the time we were looking at them or not, but there was a press-to-test knob of some sort that neither one of us could correctly identify as to function. At this time, we aren't really quite sure what it does.

ALDRIN It was a thumb depress button that seemed to go in somewhere as if it was relieving some pressure from something. I can't remember ever having seen that before. It protruded out toward your back and looked as if it might come fairly close to riding on the back of the suit.

ARMSTRONG We both thought we knew the EMU very well and knew every function and how it operated. But it turned out we were wrong. It was something that we hadn't learned there,

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ARMSTRONG (CONT'D) — and if it had been there before, somehow it escaped us. It took a little time to discuss that, and we proceeded.

ALDRIN — Mounting the 16-mm camera and the two universal brackets, one of the mirror mount and the other on the crash bar, went pretty much the way we had planned it to go. The two brackets with the enlarged knobs helped out tremendously in that I was able to tighten them down to a much greater degree than I had any of the training models. It gave me much greater confidence that the cameras would stay where I placed them and that there would be no problem with any camera banging into the window when we didn't want it to. The RCU camera brackets were difficult to tighten down. By tightening just as hard as we could, there was still a little bit of play in both of them. I think an improvement in that knob would be quite advantageous, so that it could be cinched down a little tighter. Perhaps the kind of knob that has edges that stick out so that you can get much higher torque on it would be a good thing to use.

ARMSTRONG — I think all the remainder of the EVA PREP went as per checklist.

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10.17 PLSS AND OPS PREPARATION AND DONNING

ALDRIN: The heaters tested out. Both lights came on, pressures regulated at very close to 3.7. Then when it came time to unstow the hoses, the pressures had dropped down to just about zero.

ARMSTRONG: Yes. They were below 25.

ALDRIN: Overshoes went on quite easily. We put the antifog on as soon as we got the kit out instead of waiting until a little bit later. I think that maybe there were two things that brought that about. One was that we weren't really sure it was going to appear later in the checklist, and we wanted to make sure we had that. The other was, in training, we wanted to avoid as many activities as we could with the PLSS on our back because it was very uncomfortable doing any additional exercises in one g. We did find, however, that it was quite comfortable, even without the shoulder pads, to have the PLSS mounted on your back. The mass of it was not at all objectionable. It did require moving around methodically and very slowly to avoid banging into things — no getting around it. You just couldn't always tell what the back of the PLSS or the OPS might be in contact with at any particular time.

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ARMSTRONG As was reported, we broke one circuit breaker with the PLSS and we depressed two others, one on each side, sometime during the operation with the PLSS on the back. So that's an area that we still need to improve on to be able to have confidence that the integrity of the LM itself won't be jeopardized by the operation with the PLSS on the back.

ALDRIN We had problems with this one particular electrical connector, the one that joins the RCU to the PLSS, ever since the first time we'd ever seen it.

ARMSTRONG It's about a 50-pin Bendix connector.

ALDRIN It's just very difficult to get the thing positioned properly so that the three pins on the outside, the three little protuberances, will engage in the ramp so that, when you then twist, it'll cinch on in. That must have taken at least 10 minutes. The problem was not with mine, but in hooking up Neil's. I can't say that there was that much difference in the many times that I tried it unsuccessfully and the one time it did go in correctly. It appeared to be squared away each time.

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ARMSTRONG This is not because we didn't understand the problem. We had had trouble with that connector for 2 years or more. We'd always complained about it. It had never been redesigned, and it was usually ascribed to the fact that all the training models were old and gouged, and so on. But when we looked at the flight units during CCFF on the EMU, it turned out that they were still difficult. We accepted the fact that by being very careful with that connector we could, in fact, connect and disconnect it satisfactorily. We did that in the lab at the Cape. We had a little bit of difficulty with it there. When we got on the lunar surface, it was the same problem. It took us at least 10 minutes each to mate those connectors. It's the big electrical cable from the RCU to the PLSS. It attaches at the PLSS end. It's our recommendation that it's a sufficiently serious problem that we can't afford to jeopardize the success of an EVA on that connector. And that's right now what we're betting. It began to look like we never would get those connectors made on the surface. We just have to improve that.

ALDRIN Connecting up the straps went quite smoothly. The initial COMM check out on the audio panel and the various communications checks that we made in the FM mode all

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ALDRIN (CONT'D) seemed to go quite well, until we started switching the PLSS modes. For a while, we ascribed some of the difficulty perhaps to the antenna being stowed. So we unstowed Neil's, and that didn't help immediately. A little later, it seemed to help out, but then we got back into about the same problem, so I stowed his antenna. There didn't seem to be any particular rhyme or reason to when we did appear to have good COMM and when we didn't.

ARMSTRONG It suffices to say that we never did understand what was required to enable good COMM while we were inside the cockpit, relaying through the PLSS's. We had it part of the time, and we didn't part of the time. We tried a lot of various options, and they just weren't universally successful. But we were able to have adequate COMM to enable us to continue. I think, once outside, we really didn't have any appreciable COMM problems at all. It seemed to work well.

10.20 DEPRESSURIZATION

ARMSTRONG This was one area of flight preparation that was never completely performed on the ground. In the chamber, the PLSS's were left on the engine cover and we never put them on our backs because of their weight, and the

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ARMSTRONG (CONT'D) possibility of jeopardizing the integrity of the LM. So the COMM was operated, and the connections were made, but the depressurization sequence with the PLSS's on the backs was never completed. The times when we actually operated the PLSS was done always in the chamber and never done with the LM systems operable.

So two things were new to us. One was that it took a very long time to depressurize the LM through the bacteria filter with the PLSS adding gases to the cockpit environment and the water boiler operation or something adding some cabin pressure. The second was that we weren't familiar with how long it would take to start a sublimator in this condition. It seemed to take a very long time to get through this sequence of getting the cabin pressure down to the point where we could open the hatch, getting the water turned on in the PLSS, getting the ice cake to form on the sublimator, and getting the water alarm flag to clear so that we could continue. It seemed like it took us about a half hour to get through this depressurization sequence. And it was one that we had never duplicated on the ground. Well, in retrospect, it all seemed to work okay, it was just that we weren't used to spending all that time standing around waiting.

pressure garment assembly

10.21 OPENING OF HATCH

ALDRIN Well, there's a step verifying PGA pressure above 4.5, and decaying slowly. And it did that. It decayed slowly, and the cabin stayed at around 1 psi. We had to get that down before we could open the hatch, it appeared to me. We were just waiting there between those steps of PGA pressure and cabin pressure coming down, and opening the hatch. And we didn't really want to go and open the overhead hatch. We like to open only one of them, and leave the other one the way it's been. When the hatch was finally opened, it took an initial tug on it, and it appeared to bend. The whole hatch as it opened on the far side came toward me. As soon as it broke the seal, it appeared as though I could see some small particles rushing out. Then, of course, the hatch came open and gave us a more complete vacuum. Then we went to opening the water. It seems to me that, if there is that delay to get rid of the pressure, maybe one could go ahead and open up the water ahead of time before you actually get it down to the point where the hatch is open. Maybe that would compound the problem. Once the water window did clear, it seemed that the cooling was noticeable almost immediately.

10.22 FINAL SYSTEMS STATUS

ARMSTRONG The final system status was without problems.

10.23 LM EGRESS

ARMSTRONG I guess the most important thing here with respect to the egress through the hatch and the work on the ladder and the platform is that our simulation work in both the tank and in the airplane was a reasonably accurate simulation. They were adequate to learn to do the job and we didn't have any big surprises in that area. The things that we'd learned about body positioning, arching the back, clearances required, and one person helping another and so on worked just like the real case. There weren't any difficulties in movement through the hatch or with stability on the porch.

After getting onto the porch, I came back into the LM and went up around the Z-27 corner, made sure that was as expected and it was. I returned to the porch, got on the ladder, discarded our duffle bag with arm rest and OPS pallets, released the MESA without any difficulty, and descended the ladder just as expected. The first step was pretty high; 3 to 3 1/2 feet. So the initial test

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ARMSTRONG (CONT'D) was to see if we would have any trouble getting back on the first step. There were no difficulties, so we proceeded with the planned activities. The work and effort required to go up and down the ladder and in through the hatch are not objectionable enough that they need be worried about. Going up the ladder and going through the hatch are not high-workload items. They are items that require some caution and practice. I had it a good bit easier than Buzz did because he had to go through the hatch and around the corner by himself.

ALDRIN Once I had my feet and posterior out the hatch, Neil was in good position, as good as I was to help me move out, by just observing the profile of the PLSS as it matched with the hatch opening.

ARMSTRONG The two-man operation is good because all the help that each man can give the other one is money in the bank.

ALDRIN I think the first man moving out has a little bit more difficulty because the second man has to be back behind the hatch and has to try to move it out of the way. So you have the tendency to be more over to your side away from the hatch and anything you are contacting was

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ALDRIN (CONT'D) usually on your side, your edge of the lower part of the DSKY table.

ARMSTRONG There weren't any temperature effects noted in the egress or ladder. Nothing felt hot or cold or had any temperature effects at all that I was aware of.

ALDRIN The platform itself afforded a more-than-adequate position to transition from going out the hatch to getting on the ladder. The initial step is a little bit difficult to see. When I got to the first one, I was glad to have you tell me about where my feet were relative to that first step so that I didn't have to make a conscious effort to look around to the side or underneath. What I am getting at is that operations on the platform can be carried out without concern about losing your balance and falling off. There is plenty of area up there to stand on the step and do any manipulating that might be required. There are alternate ways of bringing things up, other than by the LEC. I think there is promise of being able to bring things up over the side; straight up, versus making use of the LEC. We didn't have the opportunity to exercise those.

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ALDRIN (CONT'D)

In gravity fields, I would have come up with something closer to one-tenth, just by judging the difference in weight and feel of things in the way the masses behaved one to six. In the behavior of objects, it gives you the impression that there is a much greater difference. In my maneuvering, there didn't seem to be anything like a factor of 6 difference. It would appear as though the gravity difference was much less. What I'm saying is that it seems the human can adapt himself to this quite easily. It also appears that objects can be handled easier in 1/6g than we had anticipated. In maneuvering the objects around, they do have a certain mass. When they get going in a direction, they will keep going that way. This was evidenced when the objects were coming in the hatch on the LEC; they were fairly easy to manage, but you had to take your time in handling them.

10.24 ADEQUACY OF HARDWARE AND PROCEDURES

ALDRIN

The initial LEC operation of lowering the camera seemed to work fairly well. It appeared as though you might have been pulling on the wrong strap at first; however, we rectified that without any particular trouble.

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ARMSTRONG Initially, I had a bit of difficulty. I was not trying to get the camera up or down at that point; I was trying to pull the slack out of the line and make both straps taut. For some reason or other, it was hung up, and I had some difficulty getting the slack out of the lines. Once having done that, it came down very nicely. Here we changed the flight plan somewhat and got the camera down before doing the contingency sample. I wanted to get that camera down and hooked up while I was over there in the shadow, because to do the contingency sample, I was going to have to stow the LEC and go over into the area out of the shadow. Since I wanted to do it on the right side where the camera was mounted, I was going to have to make a trip of about 10 or 15 feet before I started the contingency sample. That's the reason we changed the order.

The operation of the suit, in general, was very pleasant. There was very little hindrance to mobility, with the exception of going down to the surface to pick things up with your hands which was a very difficult thing to do. As far as walking around and getting from one place to another, the suit offered very little impediment to that kind of progress. It was, in general, a pleasant operation.

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ARMSTRONG (CONT'D)

Thermal loads in the suit were not bad at all; I ran on minimum flow almost the entire time. Buzz found a higher flow to be desirable. This was consistent with our individual preflight experience. I didn't notice any temperature thermal differences in and out of the shadow. There were significant light differences and visibility changes but no thermal differences. The only temperature problem I had (and Buzz didn't have this problem) was with the gloves. I did not wear inner gloves. I chose to go without the inner liners in the gloves, and my hands were a little warm and very wet all the time. They got very damp and clammy inside the gloves. I found that this problem degraded my ability to handle objects and to get firm grips on things.

ALDRIN

I had cooler levels set on the diverter valve, because it just seemed to be comfortably pleasant that way. In retrospect, it appears that this leads toward a higher consumption of water. I wasn't fully aware that when you are on higher flow, you are going to be pumping more water overboard. It was not clear to me preflight that it did have that effect on your water consumption. I certainly could have operated at lower levels much sooner without

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ALDRIN (CONT'D) overheating. In confirmation of Neil's findings, I didn't experience any hot or even warm spots in the suit. I didn't wear any inner gloves, either, in my desire to get a better feel through the gloves. During the donning, I did not have the wristlets on. I thought that the LCG extending down far enough into the wrist would be adequate. If I had to repeat this effort, I would put the wristlets on, because once I was in the gloves and I started moving them around, I did find that it was rubbing a small amount on the wrist. I thought that it might get to be more annoying than it actually turned out to be, but looking back, I would have preferred having those wristlets on.

10.25 ENVIRONMENTAL FAMILIARIZATION

ARMSTRONG With respect to work on the surface, the 1/6 gravity was, in general, a pleasant environment in which to work, and the adaptation to movement was not difficult. I felt it was quite natural. Buzz had the opportunity to look at more detailed aspects of it, a good bit more than I did, but, in general, we can say it was not difficult to work and accomplish tasks. I think certain exposure to 1/6g in training is worthwhile, but I don't

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ARMSTRONG (CONT'D) think it needs to be pursued exhaustively in light of the ease of adaptation.

ALDRIN Moving around is very natural. Some attention must be paid to the mass that you have in the suit and also to the mass of the PLSS that is on your back. I think we anticipated this adequately, and the fact that we did have a sizable mass mounted to the rear was not detrimental to moving around.

10.26 WALKING

ARMSTRONG Buzz did more in that area than I did. I would say that balance was not difficult; however, I did some fairly high jumps and found that there was a tendency to tip over backward on a high jump. One time I came close to falling and decided that was enough of that.

ALDRIN There is no doubt that it was much easier to reach that neutral point by just leaning back slightly than it was leaning forward. I think the happy medium was to lean forward more than we did. It was more comfortable for us to stand erect than to lean forward to be at that absolute neutral point. The pogo tends to give you the impression that most of your moving around will be the

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ALDRIN (CONT'D)

result of toe pressures — that you will rock up on your toes and tend to push off. I did not really find this to be the case as much as I had anticipated. The 1/6g airplane is a very poor simulation of the lunar surface. There is excellent traction in the airplane, so you can't relate too much as to how the foot departs or what sort of resistance you need when you put your foot back down again. I didn't find that there was much of a slipping tendency on the surface in trying to put in sideways motions or stopping motions. It was quite natural as you began to apply a force to make a change in your momentum. I think you were able to tell just how much you could put in before you would approach any instability case. In general, it would take a couple of steps to make a good sideways change in motion and it would take two or three steps to come comfortably to a stable stationary position from a fairly rapid forward movement. To get a sustained pace evaluation, I would have had to have gone a good bit farther than I did. Before the flight, I felt that you might be able to sustain a fairly rapid pace comfortably. My impression now is that this was a little tiring on the legs. There was a rubbing in the suit somewhere in the knee joints and you had to keep

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ALDRIN (CONT'D) moving the knees, even though they are very mobile in the suit. I felt that, as easy as things looked, a 1-mile trek was not going to be an easy thing. Just by having to move your muscles and your body in the suit, you would end up getting tired on any prolonged trek. Because the terrain varies a good bit relative to your ability to move over it, you always have to be alert to what is coming up next. On earth you only worry about one or two steps ahead; on the moon, you have to keep a good eye out four or five steps ahead. I think the one foot in front of another is a much better mode of locomotion than the more stilted kangaroo hop. You can do it, but it doesn't seem to offer any particular advantage. When your feet are on the surface, you can do fairly vigorous sideways movements such as leaning and swinging your arms without a tendency to bounce yourself up off the surface and lose your traction. This was one experiment that was suggested and I found that you do tend to remain well-rooted on the surface where you are, despite motions that you may have. I guess the best thing in carrying this further is to answer the questions that people may have about certain specifics.

ARMSTRONG I went the farthest. While Buzz was returning from the EASEP, I went back to a big crater behind us. It was a

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ARMSTRONG (CONT'D) crater that I'd estimate to be 70 or 80 feet in diameter and 15 or 20 feet deep. I went back to take some pictures of that; it was between 200 and 300 feet from the LM. I ran there and ran back because I didn't want to spend much time doing that, but it was no trouble to make that kind of a trek - a couple of hundred feet or so. It just took a few minutes to lope back there, take those pictures, and then come back.

ALDRIN I don't think there is such a thing as running. It's a lope and it's very hard to just walk. You break into this lope very soon as you begin to speed up.

ARMSTRONG I can best describe a lope as having both feet off the ground at the same time, as opposed to walking where you have one foot on the ground at all times. In loping, you leave the ground with both feet and come down with one foot in a normal running fashion. It's not like an earth run here, because you are taking advantage of the low gravity.

ALDRIN The difference there is that in a run, you think in terms of moving your feet rapidly to move fast, and you can't

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ALDRIN (CONT'D) move your feet any more rapidly than the next time you come in contact with the surface. In general, you have to wait for that to occur.

ARMSTRONG And you are waiting to come down. So the foot motion is actually fairly slow, but both feet are off the ground simultaneously. You can cover ground pretty well that way. It was fairly comfortable, but at the end of this trip, going out there and back, I was already feeling like I wanted to stop and rest a little. After about 500 feet of this loping with a 1-minute stop out there in the middle to take pictures, I was ready to slow down and rest. There were a lot of interesting areas within 500 feet or so to go and look at if we had had the time. It would have been interesting to take that time and go out and inspect them closely and get some pictures, but that was a luxury we didn't have.

ALDRIN There were so many of them; it is the sort of thing you just cannot anticipate before flight. You can plan to some degree when you are on the surface, but until you get out and look around, you can't make your final decision as to what you are really going to do. Inside, you are only looking at perhaps 60 percent of the available panorama.

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ALDRIN (CONT'D) We were supposedly in a nondescript area, but there was far more to investigate than we could ever hope to cover. We didn't even scratch the surface.

ARMSTRONG I'll be interested in getting the pictures back and looking at them. I think you'll find that even though it is not a terribly rough area - it is basically a smooth area - operating around in any type of a vehicle is going to take some planning. The Moon has fairly steep slopes, deep holes, ridges, et cetera. I am sure that we can devise things that will do that, but it isn't going to be just any vehicle that will cover that kind of ground.

ALDRIN It will be interesting to see just how soon you depart from the walking-return concept. I don't think you can stretch that too far. I wouldn't guess as to what that distance is; you could give some reasonable distance you could return on foot, but it isn't miles. When you talk about miles, you are talking about being out of sight of the LM.

ARMSTRONG Another area that is not listed here is the stereo camera. I would like to make a couple of comments about that. The stereo camera worked fine. We had no problems with

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ARMSTRONG (CONT'D) it; however, it was hard to operate. I found that the angle that I had to put my hand on the handle to pull it and the force that it took was excessive.

ALDRIN The squeezing of the trigger?

ARMSTRONG Yes. I found my hand getting tired very soon while taking pictures with that camera. It was wearing out my grip.

ALDRIN Would you say that the angle was too horizontal?

ARMSTRONG Yes.

ALDRIN You would like to have had it sloped down more towards you.

ARMSTRONG Yes. It was requiring the wrist to be cocked down.

ALDRIN The initial opening up or deploying of it went quite smoothly. The extension of the handle and the opening up of the case was quite well engineered. Separating the cover, taking it off, cutting the film, and removing the cassette also went quite smoothly. I think that the big area for reengineering might be just a change in the angle the handle comes out. We might have to add a hinge or something like that to it. What about the height of the handle? That would probably not be too bad.

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ARMSTRONG I think that probably was reasonable. The other problem we had with the camera was that it was falling over all the time. I think this was the result of a little bit of difficulty in figuring out the local vertical.

ALDRIN Yes.

ARMSTRONG You'd set it down and think it was level, but apparently it wasn't, because the next time you looked it would be laying over on its side. Or you would bump it inadvertently while you were looking somewhere else and knock it over. I picked it up three different times off the surface and it's a major effort to get down to the surface to pick the thing up.

ALDRIN How'd you do that? By going down on the knee?

ARMSTRONG On one occasion I got it with the knee, one time I got it with the tongs, and the last time I had something else in my hand like a scoop or something that I could lean on and go down and get it.

In general, there were a lot of times that I wanted to get down closer to the surface for one reason or another. I wanted to get my hand down to the surface to pick up

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ARMSTRONG (CONT'D) something. This was one thing that restricted us more than we'd like. We really didn't have complete clearance to go put our knees on the surface any time we wanted. We thought the suit was qualified to do that in an emergency, but it wasn't planned as a normal operation. We didn't let ourselves settle to our knees a lot of times to get our hand on the surface. Now I think that is one thing that should be done more on future flights. We should clear that suit so that you could go down to your knees, and we should work more on being able to do things on the surface with your hands. That will make our time a lot more productive, and we will be less concerned about little inadvertent things that happen.

ALDRIN Now we can say we have the confidence to know that we could get back up from the surface. You might have to put your hand down into all this. The thing that discouraged me was the powdery nature of the surface and the way that it adhered to everything. I didn't see any real need in getting down. I had no concern about doing it. But I agree. I think if we need something on the suit to qualify it to do this, then we ought to go ahead and do that. If it doesn't, if it just

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ALDRIN (CONT'D) requires looking at the suits that we brought back and saying that they're qualified for kneeling, we ought to do that.

ARMSTRONG If you have a grip on something like a scoop, or a stick to hold on, then there's no problem at all in getting back up. You can go right down and just push on your hand and push yourself right back up. It was easy the time I did it with the scoop in my hand. That's one thing that we hadn't done a lot in our simulations, and it would be a help, I think. Let's go on with ingress.

10.35 PHOTOGRAPHY

ARMSTRONG Photography through the Hasselblads on the RCU mounts was satisfactory. I did have some trouble installing the camera on the RCU mount. The opening to the slot as you first put the tongue in the groove was binding a bit, and I always had difficulty getting it started. I'd never observed that problem on the ground, and I can't account for it.

ALDRIN I took the first panorama out in front without having the camera mounted on the RCU, and it did not appear to be unnatural to do so. It's much easier to operate with

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ALDRIN (CONT'D) it mounted; however, I didn't find that the weight of the camera was as much a hindrance to operation as preflight simulations indicated it would be. There is no doubt that having the mount frees you to operate both hands on other tasks. The handle is adequate to perform the job of pointing the camera. I don't think we took as many inadvertent pictures as some preflight simulations would have indicated. It seems as though, in all the simulations where we picked up the camera, we always managed to take pictures. I don't think that was the case in this mission as much as we thought it was going to be. We'll know if a number of the pictures taken are pointed at odd angles.

10.36 SWC DEPLOYMENT

ALDRIN I found that the shaft extended and locked back into position very easily. It folded out, deployed, and unrolled. I was able to hook it in the bottom catch without any undue shifting around. In putting it in the ground, it went down about 4 or 5 inches. It wasn't quite as stable as I would have liked it to have been, but it was adequate to hold it in a vertical position. I could make the adjustments so that it was perpendicular

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ALDRIN (CONT'D) to the Sun. The shadow that was cast by the solar wind aborted a good check in the fact that you did have it mounted perpendicular to the Sun. So I think we got a very high degree of cross-sectional coverage. When we get to surface penetrations, later, it's going to be quite evident that once you go past a depth of 4 or 5 inches, the ground gets quite hard. However, I didn't get much of a cue to this at this point while installing the solar wind experiment.

10.37 TELEVISION

ARMSTRONG The TV was operated as planned with no particular difficulties. The one thing that gave us more trouble than we expected was the TV cable; I kept getting my feet tangled up in it. It's a white cable and was easily observable for a while, but it soon picked up this black dust which blended it in with the terrain, and it seemed that I was forever getting my foot caught in it. Fortunately, Buzz was usually able to notice this and keep me untangled. Here was good justification for the two men helping each other. There was no question about that either; he was able to tell me which way to move my foot to keep out of trouble. We knew this might be a problem

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ARMSTRONG (CONT'D) from our simulations, but there just was no way that we could avoid crossing back and forth across that cable. There was no camera location that could prevent a certain amount of traverse of this kind.

ALDRIN Neil initially pulled out about 20 feet of cable and then I pulled out the rest of it. It seemed to reach a stop; it seemed to have a certain amount of resistance, and I thought that was the end of the cable. However, when I pulled normal to the opening, I found that I could then extract the cable to the point where I saw the black and white marks on it. The cable, being wound around the mounting inside the MESA, developed a set in it so that when it was lying on the surface in 1/6g, it continued to have a spiral set to it which would leave it sticking up from the surface 3 or 4 inches. It would be advantageous if we could get rid of that some way.

ARMSTRONG Your foot is continually going underneath it as you walk, rather than over the top of it.

ALDRIN One time when Neil did get the cable wrapped around his foot, the cable very neatly wrapped itself over the top of the tab on the back of the boot. That created a

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ALDRIN (CONT'D) problem in disentanglement. I don't know whether it's worth moving that tab or not.

10.38 BULK SAMPLE OPERATIONS

ARMSTRONG The bulk sample took longer than in the simulations because the area where the bulk sample was collected was significantly farther from the MESA table than the way we had done it in training. The MESA table was in deep shadow and collecting samples in that area was far less desirable than collecting them out there in the sunlight where we could see what we were doing. In addition, we were farther from the exhaust plume and the contamination of the propellants. So I made a number of trips back and forth out in the sunlight and then carried the samples back over to the scale where the sample bag was mounted. I probably made 20 trips back and forth from sunlight to shade. It took a lot longer, but by doing it that way, I was able to pick up both a hard rock and ground mass in almost every scoopful. I tried to choose various types of hard rocks out there so that, if we never got to the documented sample, at least we would have a variety of types of hard rock in the bulk sample.

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ARMSTRONG (CONT'D) This was at the cost of probably double the amount of time that we normally would take for the bulk sample.

ALDRIN I want to inject a thought about spacecraft location in respect to lunar surface working location. Putting the area of the MESA in the shadow also put the cable in the shadow. The white cable, being covered with a little bit of this powdery stuff and being in the shadow, was very difficult to observe. Consideration should be given to keeping any cable or small object out in sunlight whenever possible. It leads one to think that if you're going to yaw one way or the other, it's preferable to put your working areas out into the sunlight.

ARMSTRONG We've discussed free-launch on a number of occasions and whether we wanted to yaw specifically for lighting at touchdown. There are obviously a lot of advantages, but I was very reluctant to do any fancy maneuvering on the first lunar touchdown for selected yaw for lighting considerations. I figured we'd just take what we got and we paid for that later, because we had a lot of operations in the shadow during EVA that would have been easier had we had better lighting.

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ARMSTRONG (CONT'D) It's very easy to see in the shadows after you adapt for a little while. When you first come down the ladder, you're in the shadow. You can see everything perfectly; the LM, things on the ground. When you walk out into the sunlight and then back into the shadow, it takes a while to adapt.

ALDRIN In the first part of the shadow, when you first move from the sunlight into the shadow, when the Sun is still shining on the helmet as you traverse cross-Sun, you've got this reflection on your face. At this point, it's just about impossible to see anything in the shadow. As soon as you get your helmet into the shadow, you can begin to perceive things and to go through a dark-adaptation process. Continually moving back and forth from sunlight into shadow should be avoided because it's going to cost you some time in perception ability.

ARMSTRONG We'll start here with the flag installation. It went as planned except that the telescoping top rod could not be extended. Both Buzz and I operating together were unable to put enough force into extending the rod. It appeared to just be stuck and we gave up trying. So

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ARMSTRONG (CONT'D) the flag was partially folded when we installed it on the flagstaff. I suspect that didn't show very much on television but our still photographs should show the result of that.

ALDRIN Neither of us individually could extend it. We thought maybe we could extend the rod by both pulling, but then we didn't want to exert too much force because if it ever gave way, we'd probably find ourselves off balance. I don't know how we'll ever find out what happened. I suspect this is just something that may in some way be due to thermal conditions or vacuum welding or something like that. It came out of its mount fairly easily. I thought we had a little bit of trouble with one of the pip pins there for a while. Generally, it was a straightforward job to dismantle it.

ARMSTRONG The flagstaff was pushed into the ground at a slight angle such that the c.g. of the overall unit would tend to be somewhat above the point at which the flagstaff was inserted in the lunar surface. That seemed to hold alright, but I noted later after getting back into the LM that the weight of the flag had rotated the entire unit about the

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ARMSTRONG (CONT'D)	flagpole axis such that the flag was no longer pointed in the same direction as it was originally. I suspect that the weight of the flagpole probably had shifted its position in the sand a little bit from the position where it had originally been installed.
ALDRIN	How far would you estimate you got it into the ground?
ARMSTRONG	Six to 8 inches was about as far as I could get it in.
ALDRIN	It was fairly easy to get it down the first 4 or 5 inches.
ARMSTRONG	It gets hard quickly.

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10.39 LM INSPECTION

ALDRIN I don't think we noticed a thing that was abnormal. I guess the only thing that I made note of was the jet plume deflectors. The one on the right side as I was looking at the LM (which would make it the quad 1) appeared to be a bit more wrinkled than the one on quad 4. Of course, there's nothing to compare it with, because I'd never seen them before. As a matter of fact, the first time we really saw them was when we looked out of the command module and got a pretty good idea of their structure.

ARMSTRONG The only abnormality I noticed was (and it wasn't an abnormality) that the insulation had been thermally damaged and broken on the secondary struts of the forward leg.

ALDRIN This is true in the rear, also.

ARMSTRONG We didn't carefully check every secondary strut, but the primary struts didn't seem to be damaged.

ALDRIN Yes, in the foot passage, it didn't appear to have suffered hardly at all. There was a sooting or darkening or carboning; I don't know what you call it. At least, I feel it was a deposit rather than just a baking or singeing of the material.

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ARMSTRONG We have some pictures of the struts.

ALDRIN The part that had been melted, separated, and rolled back or peeled back on the secondary strut appeared as though it was a much more flimsy design then any other thermal covering on there. I don't think there is anything significant in the fact that part of the thermal coating that was higher up had separated, whereas the material lower down had not. I didn't notice anything peculiar about the vents. There didn't seem to be anything at all deposited on the surface from any of the vents underneath or from the oxidizer fuel vent up above.

ARMSTRONG The most pronounced insulation damage was on the front plus Z strut. Its being in deep shadow obviated the possibility of getting a good closeup picture in that dark environment.

ALDRIN I think the best pictures we got were of the minus Z strut.

ARMSTRONG There was less damage than on the examples we looked at preflight. Just the very outer layers were penetrated.

ALDRIN From what I could see of the probes, they had just bent or broken at the upper attach point. I didn't observe that they had any other fractures in them. One of them on the minus Y strut was sticking almost straight up.

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ALDRIN (CONT'D) It was pretty substantially the metal case on the outside of it, and there weren't any thermal effects noted on it at all. The inner thermal coating was trying to protect something that was relatively fragile, the flag itself; however, there was no sign of degradation on the flag. I don't remember seeing the minus Z probe. I don't know; maybe it was there.

ARMSTRONG I thought I remembered seeing all three probes. I think one was straight up and one had a V shape.

10.40 EASEP DEPLOYMENT

ALDRIN Taking the cover off the lanyard was very easy. It pulled away and didn't seem to have any thermal or blast effects on it.

ALDRIN Underneath the EASEP, the radar looked like it came through without any heat damage that I could tell. The lanyard underneath the thermal cover was in great shape. I didn't see any evidence of thermal effects. When it folded out, the doors went up even easier than the trainer. As the top door folded back, it didn't seem to fall into a detent and I tugged on it a couple of times. It looked like it was going to stay up there without any tendency to come back down again. In an effort to save some time, I elected to

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deploy both packages manually; I pulled out the seismometer a few inches, disengaged the hook, disconnected it from the top, and slid it out. I was unable to toss the lanyard over the side door to keep it out of the way, so it did come down from the boom and had a tendency to get in the way. The package itself was quite easy to manage. I had my left hand on the handle and moved the right hand around to support the weight as it slid off the rails. It was disengaged quite easily from the boom at the pip pin. I had it down on the surface, and then to get ample maneuvering room to get the retroreflector down, I decided that I wanted to move the seismometer away. However, there happened to be a small crater right there, so I had to move it maybe 10 feet away and come back. Remember, it didn't seem to be a good place to set that seismometer down, other than right in front. It appeared to be in my way a little bit. In pulling out the laser package, I used the same technique, pulling out a few inches, then disconnecting the lanyard from the package itself, then pulling the string that was attached to the pip pin. In training sessions, I had pulled this one rather slowly and firmly and had a few problems with the pip pin binding. The recommendation was to give it a fairly good jerk. When I did this, the wire ring that attached the cord itself to the pip pin sprung open. Either it was a welded

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joint that separated or thermal effects somehow weakened it; but it opened up and came loose from the pin. I was able to get the pin out by depressing the one side. Then by pushing it with my right hand and pushing it through, it came loose. Then I lowered it down to the surface and again it was quite easy to handle. The boom slid back in with no problem. I left the lanyards dangling out the bottom, pulled the retract lanyards, and the doors came back down and fitted together very nicely. The whole operation was quite smooth and I thought we got a little bit ahead in time in the deployment of these things. I picked up the two packages and we headed out to the minus Y strut looking for a relatively level area. Looking for level areas, I found it difficult in looking down at the surface and saying exactly what was level. I don't know what to attribute this to particularly. You don't have as good a horizon definition as on the earth. When you look out to the side, you've got a very flat area on the Moon. When you look out to the edges, you've got varying slopes. I think it's further compounded by the fact that with 1/6g, and a center of mass displaced considerably aft and up from where it normally is, your physical cues of supporting your weight are different. The result was that it was just a little bit difficult to tell what was level and what was sloping, either to one side or up or down.

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ARMSTRONG You don't have as strong a gravity indication either, I don't think.

ALDRIN Yes. It doesn't have as firm an orientation. That pretty well covers the deployment out to the site. In going through the numbers of pulling the little lanyards, everything progressed as neat as can be. The handle deployed upward and rotated around, even though I wasn't able to see it fit into its slot. This is the maneuvering handle on the PSE. I might point out that the flight article was different in configuration than the training package, the difference being that you couldn't see when the handle was out and locked in its detent as well on the flight package as you could on the training package. Anyway, this worked out quite well. Orienting the package in azimuth was quite easy. The shadow of the gnomon stood out quite well in our session in the lab with the flight packages. We had had some concern as to just how well this shadow was going to stand out against this silver surface. However, all three of the pins in the gnomon were quite clear. I won't say they were a very crisp shadow, as there was a little bit of fuzziness to them, but it was quite easy to determine where the center of it was and get it orientated at the 45-degree mark. The big problem arose in trying to get the BB to settle down into the center of its little cup.

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ALDRIN (CONT'D) It seemed to want to find a home away from me at about 11 o'clock as I faced the package. I would try to push it down to get it to rotate around and it would move away from this position and start spinning around the outside. Try as I would to move it gradually away or push down on the package (away from where the bubble was) to get it to drift across, I was completely unsuccessful in getting the BB to find a home anywhere but along the perimeter. As I would bend down and look at this thing, it just appeared that this cup, instead of being concave, had somehow changed its shape and was convex. It didn't appear that there was any hope of the BB ever being anywhere but along the edge, so I visually tried to level it as best I could. As I indicated before, that wasn't too easy to do with any degree of confidence. Then I went to deploy the panels. One of the two retaining structures that should have fallen away when you right the package (both should fall down exposing the panels) failed. So I walked around the package and easily reached down with my finger and flicked it loose. It didn't require much force at all. When I deployed the panels, the left one came out and deployed completely; then following another pull on the lanyard, the right one deployed. There was a certain amount of rocking motion and dancing around on the surface as the two deployed panels flung themselves around before

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ALDRIN (CONT'D) finally settling down. During the process of doing this, I believe two of the four corners came in contact with the surface and picked up a light coating of surface material. I'd say the triangle that was coated might have been 2 inches on one side and maybe 1 inch on the other — a very small triangle. So I don't think there was much degradation at all on the surfaces with that particular coating. I made one final inspection and, when I left it, the BB was still sitting on the edge. Neil came by with the camera to photograph it and he looked at it and found the BB was sitting right in the center of it. I have no explanation for that at all.

ARMSTRONG It would have been nice to have a big rock table to set those packages on, but there wasn't any. The area where they were placed was a ridge between some shallow craters. I think we have reasonably good pictures of those ridges. They have this same kind of soil consistency as the surrounding area. The packages were in essentially soft material which allowed us to jiggle them down and get them reasonably well set into the sand, but there is no knowing whether they will stay there for a long period of time or might slowly settle.

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ALDRIN I think that they retained their present position pretty well. When I decided that I wanted to change the slope of the package one way or another, I found that I had difficulty in getting it to sink down a little more on one side. Even by scraping it back and forth, I couldn't seem to lower one edge as much as I would have liked to have.

ARMSTRONG There was no difficulty in the laser reflector installation. It worked as we expected.

10.41 DOCUMENTED SAMPLE COLLECTION

ALDRIN Let's discuss the documented sample. We were obviously running out of time at the end of the EASEP deployment. We had limited time to conduct the dôcumented sample. A figure of 10 minutes was used. I thought we might actually progress in a formal excursion and get something started anyway. As the box was opened, we got the report that they wanted two core tubes and it looked like that was probably going to take most of the time. While I proceeded to that — because that's essentially a one-man operation — Neil went around the backside of the LM and picked up what rocks he could identify, getting as wide a variety as possible. In unpacking the box with the core tubes, I was quite careful to try to identify where the caps were. In some simulations, we had misplaced them or they had dropped to the surface.

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ALDRIN (CONT'D)

I do think we need a better way of identifying the various packages that have this packing material wrapped around them, so that at a glance you'd know what is inside a certain roll. In many cases, there is nothing in it. In other cases, it's got an environmental container in it, or it's got the caps to the core tubes. In putting the extension handle on the core tube, the first one went on fairly cleanly and locked into position with a fairly high degree of confidence that it was not going to come out. I won't say that there was complete certainty that they were not going to come apart. I then picked up the hammer, went out into the vicinity of where the solar wind experiment was, and drove the first core tube into the ground. I pushed it in about 3 or 4 inches and then started tapping it with the hammer. I found that wasn't doing much at all in the way of making it penetrate further. I started beating on it harder and harder and I managed to get it into the ground maybe 2 inches more. I found that when I would hit it as hard as I could and let my hand that was steadying the tube release it, the tube appeared as though it were going to fall over. It didn't stay where it had been pounded in. This made it even harder because you couldn't back off and really let it have it. I don't know if we have any way of measuring the exact force or impact that

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ALDRIN (CONT'D) was applied other than subjective. Maybe watching television would be some help. I was hammering it in about as hard as I felt I could safely do it. Unfortunately, we don't have any of the surfaces on the extension back to look at the impact. I was hitting it with the hammer to the point that I was putting significant dents in the top of it. I didn't find any resistance at all in retracting the core tube. It came up quite easily. On rotating it up to the inverted position to keep anything from coming out, I didn't find any tendency at all for the material to come out of the core tube. When I unscrewed the cutter, the surface seemed to separate again without any tendency for the material to flow or move. This meant that the consistency of this material, even though it looked to be about the same, was a good bit different. If I had some very close surface material and shifted it a little, it would tend to move from one side to the other. At the bottom of the core tube, I had the distinct impression—and it's just a descriptive phrase—that this was moist material. It was adhering or had the cohesive property that wet sand would have. Once it was separated from the cutter, there was no tendency at all for it to flake or to flow. I put the cap on, put it away, and then went to another area I would judge 10, maybe 15 feet away. I

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ALDRIN (CONT'D) encountered about the same difficulty in driving the tube in. I imagine it went in about the same depth. It struck me that when I was removing this core tube from the extension handle, it was coming off. I had less confidence in initially putting the two together that they were going to stay together properly. When I was removing it, it appeared as though the end of the core tube that attaches to the extension handle had a tendency to come off. I had noted this earlier in some of the bench checks. When you screw the core tube in, if you aren't careful when you disengage it you're liable to disengage the cap on the other end. And the reason I'm belaboring this particular point is because I understand that one of the ends did come off. I guess I can't be sure that it did not come off at the time of disengaging. Perhaps it could have come off in the box, but I don't believe they found the other end. So the assumption is that when it was taken off the extension handle, the other end came off with it. It doesn't appear as though the material spread around inside the box because none could be found, so it must have adhered pretty well. Did we get photos of both those areas?

ARMSTRONG I did not get stereopairs. I got one photograph of the second one. Well the first one to a high degree of

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ARMSTRONG (CONT'D) confidence was right in the area of the SRC. We can identify its location pretty well by the photograph. The solar wind disengaged from its staff quite easily. When it rolled up, it had a tendency to sneak off to the side and crinkle on the edges. I spent some 20 to 30 seconds unrolling it and trying to get it to go up a little smoother. I then remembered that they really didn't care about exact neatness. All they wanted was the material back because they were going to cut it up in many pieces anyway. So I bunched it together and it slid into its container fairly easily.

In regard to the SRC height, we couldn't tell, due to the insulation, just what it was; but we gave the height of our ladder above the ground. The photographs would fill in the story there.

ALDRIN It might be advisable to have some simple measuring device. It wouldn't take very much. Perhaps by the use of some marks you just make a judgment whether the distance between the 3 and the 4 is the same as between the 4 and the 5 or whatever the sequence might be.

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10.42 SRC

ALDRIN The SRC's worked as planned. The only difficulty that I encountered was in closing the boxes. Opening the second one, I felt, required a little more force than I had anticipated in just lifting up the lever lock.

ARMSTRONG Closing the bulk sample box took a lot more strength than I had expected. It took just about everything I could do to close the document sample box. I was afraid I might have left the seal in the box. I don't think I did because, at the time, I thought I remembered clearly taking the seal off and throwing it away; but that's what it felt like. I inadvertently tried to close one with the seal in place at one time during training, and this was very much the same kind of situation. It took an inordinate amount of force. There's another difficulty in the fact that the gravity is so low that the box tends to slip around very easily. It feels very light; skids away from you. So, in addition to closing it, you have to hold it firmly down on the table. The table's not very rigid. It's quite flexible. So just holding the box securely enough in position to apply the high force on the sealing handles was some trouble.

QUESTION: Compare lunar versus Earth gravity.

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ALDRIN Subjectively comparing the weight of the boxes (following removing them from the spacecraft on the carrier), I would say closer to one to ten — just judging the differences in weight and feel of things and the way the masses behaved. One to six gives you the impression there is a much greater difference than that. Now in your own maneuvering around, it doesn't seem to be anything like a factor of six in the ease in being able to do things. It would appear as though the gravity difference was much less. What I'm saying is that it looks like the human can adapt himself to this quite easily. It also appears as though the handling of objects is considerably easier in 1/6g, as we had anticipated. In maneuvering objects around, they do have a certain mass. When they get going in a direction, they will keep going that way as was evidenced when they were coming in the hatch on the LEC. They are fairly easy to manage, but you have to take your time in handling them.

10.44 LM INGRESS

ALDRIN Stability and balance: Well, the first step up to the bottom rung no doubt is a pretty good step, though Neil tells me he got up to the third one.

ARMSTRONG The third step.

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ALDRIN The capability exists to do a good bit more in terms of a vertical jump than certainly the POGO leads you to believe. There's no way to evaluate that in the airplane. The big problem in the POGO was that it just didn't seem to be able to bring you down with enough to bear so that your inertia would carry you as far as it's able to with good leg extension.

ARMSTRONG The technique I used was one in which I did a deep knee bend with both legs and got my torso down absolutely as close to the foot pad as I could. I then sprang vertically up and guided myself with my hands by use of the handrails. That's how I got to the third step which I guess was easily 5 to 6 feet above the ground.

he jumped 5 or 6 ft.?

ALDRIN The rungs of the ladder were not in any way dangerously slippery. Material on the bottom of your boots tended to cause them to slide back and forth.

ARMSTRONG They were a little slippery.

ALDRIN I think we have already mentioned the adequacy of the platform for other operations, that is, alternate ways of bringing things up. The hatch moved inward very easily. As I faced the hatch, I moved the camera from its position on the right side of the floor, up onto the Z-27 bulkhead.

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ALDRIN (CONT'D) I had very little difficulty, again using the same technique that Neil used. About half way in, make concerted effort to arch your back to keep the PLSS down by keeping your belly down against the floor. This affords you the least profile going in. There didn't seem to be any exertion at all associated with raising yourself up and transitioning to a point where you can bring your knees on inside the cockpit, and then moving from a kneeling to an upright position. It all seemed to work quite smoothly. When there is a large bulk attached to you, you have to be careful. Once you get inside, before you start to turn around, you must make adequate allowance for all this material behind you.

ARMSTRONG That was an interface problem. As a matter of caution, each person should be helping the other as much as possible. The first man in has the biggest problem, at least when he gets inside the cockpit. He has nobody to help him with clearance and I'm sure he must use a good bit of caution.

ALDRIN The LEC didn't seem to get in the way at all while I was getting in. We had the mirror available, but I don't think either of us found any particular use for it.

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10.45 EQUIPMENT JETTISON

ARMSTRONG I don't racall any difficulties with that.

ALDRIN Well, this period was prolonged a bit to try to make as much use of the film remaining. I think we probably took more pictures than we should have in an effort to make sure that we covered each particular window as thoroughly as possible and with as wide a range of settings as we could before we proceeded to jettison the camera.

ARMSTRONG I think the equipment jettison went well and as planned.

ALDRIN We made an LiOH change at this point.

ARMSTRONG We included the canister as a separate jettisonable item at this point, which we had planned to do before the EVA.

ALDRIN We elected to leave the helmets on because at this point there was so much stuff rattling around inside the cabin that they would have added just one more bulky item. The primary canister change proceeded quite well to the point of inserting the new canister. I ran into a minor problem in getting it to rotate fully so that I could get the cover on. When it finally did seat itself in properly, I can't for sure identify what I did differently from the times when it didn't seem to rotate. That seemed to be what

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ALDRIN (CONT'D) was stopping the cover from going on completely, the fact that when the canister was inserted I couldn't seem to rotate it as much as I thought it should have been rotated. However, the canister container behind the ascent engine removed very easily, and we were able to jettison it without any problems. We didn't have any problem; I didn't notice you had any difficulty giving the packages the heave-ho. I think each PLSS bounced once on the porch before it went on down.

ARMSTRONG Only one thing stayed on the porch. That was a small part of the left-hand-side storage container that did not make it off the porch onto the surface. That was the last item jettisoned. Concerning the LEC, I had neglected to lock one of the LEC hooks which normally wouldn't have caused any trouble. You would expect to proceed normally whether that was locked or not. However, for an unknown reason when I got the SRC about half way up, the Hasselblad pack just fell off. I can't account for that. I just took the pack on up and attached it, and ensured that it was locked when I put it on the SRC the second time. When it fell onto the surface, it was covered with surface material.

ALDRIN I'm sure there is a lot of inertia with any package like that and, with that low gravity, it tends to swing back

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ALDRIN (CONT'D) and forth; and if there is some tendency to reach an unlocked position, it will.

ARMSTRONG There was no problem because the ladder was right there, so I just leaned over and down to the ground and picked it up. I had the ladder to hold on to and then I could push myself right back up to a standing position.

ALDRIN Did the film magazine hit the pad or drop right to the surface?

ARMSTRONG I think it hit the surface clear of the pad, on the right side, which would be the spacecraft's left. I wasn't worried about the contingency sample because that was inside a bag. If anything was going to catch fire, it was going to be my whole suit because it was just covered with that stuff.

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10.46 POST-EVA CONFIGURATION

ARMSTRONG The post-EVA checklist went very well. It was well planned and we went precisely by the preplanned route with possibly a few exceptions. They went very well and probably took about the same or a little more time than we expected. Of course, the time period that we took while we were waiting for the canister before starting the repressurization was comparably long. We had to put an eat period in there as I remember and took a lot of pictures.

ALDRIN Well, there's no getting around it, it's another EVA PREP exercise. It's easier, but you still have to go through the same exercises such as pressure-integrity check, reading the cabin down, and configuring the ECS. I guess if you have two EVA's, it probably would be nicer to jettison your equipment at the beginning of the second one, rather than having to add another DEPRESS. I'm not sure how they're planning to do this.

ARMSTRONG There still was a full truckload of equipment inside that cockpit at the end of EVA. It's just a bunch of stuff, and I was glad that we were able to get rid of a lot of it and finish the jettison before we started our sleep period. With all that stuff in the cockpit, there's really no place left for people to relax.

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10.50 UPDATES FOR LIFT-OFF

ALDRIN On P57 before lift-off, the Sun moved up in the field of view, as did all the rest of the stars. The Earth stayed the same. The Earth obscured the forward detent and the right detent. The Sun was now in the rear detent, and for some reason, it also obscured the left-rear detent, which was the one I was counting on using with Rigel. This was the one we had used before. I was quite surprised to discover this. The Sun was not within more than 15 degrees of the total field of view. It completely obscured the left-rear detent. It effectively left us two out of the six detents to pick stars from. Looking at those two detents, there weren't any stars near the center. The closer to the center of the detent you get the greater the accuracy is. The day before we had used Navi and it wasn't particularly bright. So I went back and now could use Capella, but it was fairly close to the edge of the field of view. So we did a gravity/one-star alignment and that first gravity alignment came up with 00010. VERB 32 gave us 00001. We used a sequence of marking that involved an onboard averaging of five successive cursive readings, followed by depressing the MARK button, and then five successive spiral readings that Neil would log down as I would read them off. Then he would

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ALDRIN (CONT'D) average these up and we would put them in. We'd use either spiral or cursive first, whichever appeared to be convenient.

I think this averaging technique worked out better than letting the computer do it, because it would have amounted to a considerable rotating of the spiral and cursive reticle field back and forth to make one spiral, then a cursive, then a spiral, and do a recycle. There is the option, however, to do one or the other. This was a REFSMMAT alignment. The torquing angles were fairly large, the star-angle difference was 00007 which preflight was the expected value of a two-star alignment. Torquing angles were very close to 0.7 in all three axes, which indicated that the platform did drift a fair amount during that time period. We then did the P22. I had hoped at that point to use the AGS to tell me where the command module was, but unfortunately we didn't update the AGS with the latest PGNS state vector so it wasn't giving us good range and range rate. I would recommend doing that, if anyone does a P22 in the future, because you can't use the PGNS to tell you what the range and range rate are. And you can't use the radar because it's not going to lock on until it gets to 400 miles. But the AGS gives

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ALDRIN (CONT'D) you very good indications as you are approaching that range. So we were a little misled and I thought we were still well out of range when we finally got the lockon.

You call up the program before the command module gets to 400 miles. It sits and waits; and, when it gets less than 400, it locks on automatically, and you see the signal strength grow and it starts to track. But it's in mode 2 so you don't see the needles doing anything; the cross-pointers move, indicating it's got rate drive going as it's trying to keep up with it. Because we didn't want to run the tape meter into the stops, we left it in ALTITUDE/ ALTITUDE RATE.

We really didn't have much of an indication that any good information was coming in, other than signal strength. I guess the ground got the data on the downlink. When it broke lock, I thought the command module was overhead and it had broken lock because of a maximum rate drive. The radar representative from RCA had indicated that the SPEC said it might break lock, but he didn't think it would as it went over the zenith. But, because of the AGS indications, I thought that was what had caused the break-lock. Evidently, it had gone out the front field of view. It broke lock just a short time after the time given us by

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ALDRIN (CONT'D) the ground for the zenith passage. So I was fully expecting it to acquire again. I don't think we had our AGS configured and the ground was not as helpful as they might have been had we run this sort of thing previously in simulations and had a bit more training on it.

We started to do the P57 and realized that this would be too soon before lift-off. It seems to me we had a time period in which we were essentially standing by. We did an abbreviated RCS check. Because one of them was a cold-fire check, we got all the red flags coming on. We did an AGS calibration, got the ascent pad; then, at about 45 or 50 minutes before lift-off, we called up the P57 again.

We did a landing site option at the TIG of lift-off. The torquing angles between this alignment and the previous one were on the order of 0.09 degree maximum. The gravity alignment had an initial error of 0.00001 and on recycle had the same thing. I don't have logged down what the star-angle difference was, but it was - probably on the order of 7 to 9, somewhere in there. It wasn't anything that made me jump up and down. But again it was measuring the difference between gravity and a star and, of course, doesn't really indicate how well you know the star position

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ALDRIN (CONT'D) or how well you measured that, because it's relative to how well the gravity was measured.

We had an update concerning the position to leave the radar for ascent. We were instructed by the ground not to turn the radar on during ascent and to leave it in SLEW.

I think we left the circuit breakers out. This was to keep from overloading the computer, in a similar way to what had happened during the previous day during descent. I think that's unfortunate that we do have to deprive ourselves of one additional check for insertion confirmation. There was one more venting of the descent tanks at insert — lift-off minus 30 minutes. I had the radar in SLEW and the circuit breakers off.

ARMSTRONG I'm quite sure they were off.

ALDRIN Well, I didn't want us to use the tape meter in PGNS. Now that would have given us altitude and altitude rate out of the PGNS, right? So they didn't want to burden down the PGNS with doing that. Here I have on the circuit breaker card, leaving both radar ciruit breakers open.

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ALDRIN (CONT'D) We got the batteries on the line a little sooner because I think the ground thought that they might have cooled down a little bit more than their preflight information might have indicated. So we brought those on before TIG minus 30.

Another change — we lifted off with the updata link in VOICE BACKUP, brought the VHF ranging on at TIG minus 15, and pressurized the APS tanks. I guess it slipped my mind, perhaps Neil's too, that the Apollo 10 crew had noted that they saw very little decrease in the helium pressure. At first, it looked like we had about a 100-psi decrease in Tank 1 and zero decrease in Tank 2. That was probably the worst thing we could have seen because we figured that just one tank had pressurized. The ground was a little concerned about that. If they were not concerned, I wish that they had given us just a little bit more comforting thoughts at that particular time, because we hesitated at that point, at least I did, in doing some more of the switch configuration, waiting for a confirmation from them.

10.51 GENERAL LUNAR SURFACE FATIGUE

ARMSTRONG I wasn't tired at all. I worked real hard at a high workload right there near the conclusion when I was pulling the rock boxes up. We knew that was going to be hard,

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ARMSTRONG (CONT'D) plus the fact that we were racing around a little bit towards the end, trying to get everything thrown into boxes and getting all the pieces put together. I expect my heart rate ran up pretty good right there, but I had a lot of energy and reserve at that point, because we had been sort of taking it easy all through the EVA. Everything was, with a few small exceptions, accomplished with a comfortable workload. We didn't have to work hard throughout the whole timeline, and I knew I could afford to race around there for 5 or 10 minutes without jeopardizing the operation at all. They called for a status check and I gave them one and we proceeded, but there wasn't a problem with respect to available energy and reserve.

ALDRIN I think the fact that you're well cooled off enables you to absorb a fair amount in an increase of activity before it manifests itself. The oxygen flow rate concerned me a little bit preflight because I found, in doing some fairly strenuous exercise in the thermal vacuum chamber, that the first indication I got was that there was not quite enough circulation of air or oxygen to breathe. It tended to get a little stuffy in the helmet.

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ALDRIN (CONT'D) I think all of us who have been through this business know a good bit about the pace of activities following insertion, which is rather leisurely taken. However, you can get wrapped around the axle doing a lot of different things that aren't required — many of them are doing things just to say, "Yes" — you can add more and more solutions. Therefore, to carry out a minimum-rendezvous effort is not, as I would see it, a very tiring task to look forward to after descent and a prolonged EVA. I think we would have been fully capable of carrying out a lift-off and rendezvous.

ARMSTRONG We handled one.

ALDRIN You just are not going to get any sleep while you're waiting for it to be completed, but you're certainly not going to be completely bushed chasing yourself around the cockpit. With the automatic radar lift-off and rendezvous are fairly leisurely exercises. I guess I'd have more concern about Mike's ability to continue, because he's quite active moving back and forth and doing a lot of manual tasks with the sextant that we didn't have to do.

ARMSTRONG We cleaned up the cockpit and got things pretty well in shape. This took us a while and we had planned to sleep

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ARMSTRONG (CONT'D) with our helmets and gloves on for a couple of reasons. One is that it's a lot quieter with your helmet and gloves on, and then we wouldn't have any mental concern about the ECS and so on having two loops working for us there.

ALDRIN We wouldn't be breathing all that dust.

ARMSTRONG That was another concern. Our cockpit was so dirty with soot, that we thought the suit loop would be a lot cleaner.

ALDRIN I guess the question is — Can you keep it cleaner? I guess you could keep it a little cleaner, but there are so many things going in and out that it's almost impossible to avoid getting a significant amount of lunar material in there.

ARMSTRONG A couple of comments with respect to going to sleep in the LM: One is that it's noisy, and two is that it's illuminated. We had the window shades up and light came through those window shades like crazy.

COLLINS Why didn't you pull the window shades?

ARMSTRONG We had them closed. A lot of light comes through the window shades. They're like negatives and a lot of light will shine through.

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ALDRIN You can't see what's going on outside, but you can come quite close to it.

ARMSTRONG For example, you can see the horizon out there through the window shades. There's that much light that comes through. The next thing is that there are several warning lights that are very bright that can't be dimmed. The next thing is that there are all those radioactive illuminated display switches in there. Third, after I got into my sleep stage and all settled down, I realized that there was something else shining in my eye. It turned out to be that the Earth was shining through the AOT right into my eye. It was just like a light bulb. If I had thought of that ahead of time, we could have put the Sun filter on or something that would have cut the light out.

The next problem we had was temperature. We were very comfortable when we completed our activities and were bedded down. Buzz was on the floor and I was on the ascent engine cover. We were reasonably comfortable in terms of temperature. We had the water flowing and the suit loop running. We had to have the suit loop running because our helmets were closed. After a while, I started getting awfully cold, so I reached in front of the fan and turned the water temperature to full up, MAX increase.

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ARMSTRONG (CONT'D) It still got colder and colder. Finally, Buzz suggested that we disconnect the water, which I did. I still got colder. Then I guess Buzz changed the temperature of the air flow in the suit.

ALDRIN Yes. We fell victims to a time constant. Once we noticed it going bad there wasn't anything we could do about it. In addition, because we were trying to minimize our activity and stay in some state of drowsiness, we didn't want to get up and start stirring around because it would be that much harder to get back to that same state again. So we tried to minimize our activity. We underestimated how much light was coming in through the windows. There must have been a significant amount of light and heat coming in and just being reflected off the surface. We had no feel for what gas-flow setting we should have had, because we'd been on the cooling all the time up to that point while moving around. I'm not sure that there's much control over that anyway. We finally disconnected the oxygen flow.

ARMSTRONG But that requires you take your helmet off, so that you can breathe when you turn the suit disconnects. This means that it gets noisy again, and all you hear is a glycol pump and stuff like that. This was a never-ending

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ARMSTRONG (CONT'D) battle to obtain just a minimum level of sleeping conditions, and we never did it. Even if we would have, I'm not sure I would have gone to sleep.

ALDRIN I don't know who was on BIOMED at the time, but I feel that I did get a couple of hours of maybe mentally fitful drowsing. I'll have to say that I think that I had the better sleeping place. I found that it was relatively comfortable on the floor, either on my back with feet up against the side or with my knees bent. Also, I could roll over on one side or on the other. I had the two OPS's stacked up at the front of the hatch, so there was ample room on the floor for one. But there wasn't room for two.

To cut down on the light level, we're just going to have to do something with the window shades to make them more effective. I think sleeping with the helmet will keep the cooling down and is probably a good reasonable way to go as long as you're going to keep the suit on. Unless some change is made, we'd never even think about taking the suits off.

COLLINS Apollo 12 is planning to take their suits off. With the longer stay-time and a couple of EVA's, they're planning to take their suits off.

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ALDRIN I think they ought to think a little more about it. I don't know what the temperature would be in there. I got the impression that it was a lot cooler outside the suit than it would have been inside. I don't feel that having the suit on in 1/6g is that much of a bother. It's fairly comfortable. You have your own little snug sleeping bag, unless you have some pressure point somewhere. Your head in the helmet assumes a very comfortable position. Even out of the helmet, you don't have to worry about what you're leaning against. Your head doesn't weigh that much, and will very comfortably pick just about any position. I just don't see the real need for taking the helmets off.

ARMSTRONG I didn't mind sleeping on the ascent-engine cover. I didn't find it that bad. I made a hammock out of a waste tether (which I attached to some of the structure hand-holds) to hold my feet up in the air and in the middle of the cockpit. This kept my feet up about level with or a little higher than my torso.

ALDRIN Well, you were back out of the mainstream of the light except for the windows in the AOT. I think we could fix that up and obtain a more horizontal position or the capability to roll from one side to the other. That's

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ALDRIN (CONT'D) just something that has to be worked out. It wasn't satisfactory. If we had known then what we know now, we could have preconditioned the cabin a little bit better. We needed to start at a warmer level by turning the water off, thereby storing a small amount of heat.

ARMSTRONG That's just one of those areas that didn't occur to us. It clearly needs some more work.

10.53 LEC

ARMSTRONG The LEC worked as expected; however, I have a few comments worth noting. The primary one is that the LEC was a great attractor of lunar dust. It was impossible to operate the LEC without getting it on the ground some of the time. Whenever it touched the surface, it picked up a lot of the surface powder. As the LEC was operated, that powder was carried back up into the cabin. When the LEC went through the pulley, the lunar dust would shake off, and the part of the LEC that was coming down would rain powder on top of me, the MESA, and the SRC's so that we all looked like chimney sweeps. I was just covered with this powder, primarily as a result of dirt being thrown out by the LEC. This also tended to bind in the pulley. I felt like there was enough silt collecting in the pulley that

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ARMSTRONG (CONT'D) it was actually binding. Fortunately, Buzz was able to help a great deal. He actually put the majority of the forces into pulling the boxes up from the top end, rather than me from the bottom end. I was standing at a very severe angle, which prevented me from using as much force as I had planned for pulling. The ground was too soft and my feet slipped easily. I was leaning over at approximately a 45-degree angle. I had one foot behind me so that if my foot slipped, I wouldn't fall down.

The surface was worse. I think the angle and so on were about the same, but I did not have the footing. I couldn't get the footing in this soft powder that you needed to do that job.

ALDRIN There are several points that tend to make footing more difficult. One is the powdery, graphite-like substance. When it comes in contact with rock, it makes the rock quite slippery. I checked this on a fairly smooth, sloped rock. It was quite easy to get this material on it, and the boot would slip fairly easily. That factor tends to make one more unstable. The second point is that the surface may look the same, but we found that in many areas (with just very small changes in the local surface topography) there

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ALDRIN (CONT'D)

would be unexpected differences in the consistency and the softness of this top layer. For example, we might find in some areas where there was just a small slope that when we were on the edge of this slope, there would be little change in the thickness or depth at which we penetrated. In other places, we would find we had put our feet down and we would tend to depress this surface to a new location, as if there were a different depth of the more resistive subsurface. These two factors gave us a low confidence level in our balance and footing setups.

To keep the LEC coming smoothly on the inside and to have my pull on it in the appropriate direction so that it neither tangled up near the pulley end nor tended to move or slide the pulley as it went out the hatch, I found that I was completely unable to look out the window at the same time. It was a question of my looking at the LEC, talking to Neil, and hoping we were coordinated. It would be nice to work this over more and try to find some way to maintain visual contact back and forth. I didn't find that easy to do.