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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

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.

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

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;

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.

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.

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.

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.

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

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.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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 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.

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

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

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

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.

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

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.

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.

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.

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.

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.

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.

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.

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.

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

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 pitchdown, 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.

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.

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

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.

CONFIDENTIAL

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.

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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

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

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.

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.

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

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.

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.

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

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 sideways. 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.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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

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.

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.

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

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?

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.

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

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

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

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

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.

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

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

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.

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.

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.

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