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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



APOLLO 11 TECHNICAL CREW DEBRIEFING (U)

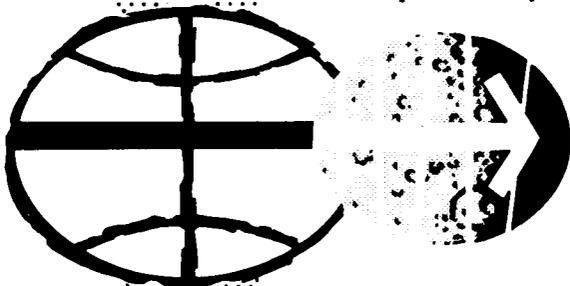
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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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MJC memo 11-17-71
H.R.M. 12-27-71*

11.0 CSM CIRCUMLUNAR OPERATIONS

11.1 OPERATIONS OF SPACECRAFT

COLLINS In general, CSM circumlunar operations went smoothly, and there were no surprises. The spacecraft operated normally; it didn't have any failures.

11.2 NAVIGATION

COLLINS There wasn't much navigation to be done. I did use P21 several times to pin down the time of arrival at the 150° W meridian, which was the prime meridian on the map. It was a simple and easy thing to use P21 to get that information and update the map. The map worked fine with the time tick marks, as long as you are in an orbit of approximately 2 hours' time. The map is a useful tool in helping locate where you are with respect to the ground.

11.3 LANDMARK TRACKING

COLLINS The operation of P22 was easy. The procedures that I had condensed into a checklist on the LEB panel were more than adequate. I always went to P22 early, got AUTO optics, and pointed at the landmark far in excess of 50 degrees trunnion. I sat there with a PROGRAM ALARM until such time as the trunnion angle came down below 50 degrees. At this time, I punched off the PROGRAM

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ALARM, and the optics then began to track. I found this was an easy way to operate the system. I had the center couch underneath the left-hand couch for EVA. It was easy to move from the LEB up to the MDC. I found that window 2 or preferably window 3 could be used to give you an idea of where you were relative to the landing site. I could look out either of those windows and see all the landmarks approaching. When I got fairly close, all I had to do was leisurely wander down to the LEB, look through the optics, and be ready to mark. The problem was I didn't know where the LM was, and the ground didn't either. There is too much real estate down there within the intended landing zone to scan on one, two, three, or four passes. On each pass, I could do a decent job of scanning one or two grid squares on the expanded map. That map is the 1:100 000 map called LAM 2. The ground was giving me coordinates in the grid square coordinate system that were as much as 10 squares apart. This told me they didn't really have much of a handle at all on where the LM had landed. As I say, it was just too large an area for me to visually scan. I used AUTO optics each time I looked at the area they suggested. I never did see the LM. I don't have any suggestions for future flights. You have to know with considerable accuracy

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where the LM is before you can mark on it. If you knew where it was that accurately you wouldn't really need P22 to refine your estimate. Perhaps a different Sun angle would yield the possibility of a flash of specular light off the LM skin giving you a clue. I looked for flashes and never saw any.

11.4 MSFN

COLLINS

MSFN worked fine. I was using AUTO on the high-gain antenna. It worked well. The ground was conscientious in updating AOS and LOS times. I don't think that's really necessary. If you're in a near nominal trajectory, as we were, it's an easy thing to do if you have good COMM. If the COMM is intermittent, you can waste 4 or 5 minutes trying to read back and forth AOS and LOS times which really are not required. When the LM is on the surface, the command module should act like a good child and be seen and not heard. The communications with it should take on a negative reporting method.

11.5 PLANE CHANGE

COLLINS

Plane change was not required. The plane change procedure of uplinking a new REFSMMAT and gyrotorquing the platform around to that new REFSMMAT is a tedious procedure. I'm not sure that the gyrotorquing is the way

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COLLINS
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to go. A few days before the flight, we abandoned that gyrotorquing method in favor of coarse aligning to the new REFSMMAT. The gyrotorquing took an excessive period of time and had no protection against gimbal lock. We could not even predict in which direction the platform would gyrotorque. That was the story we were given. Some thought should be given to a better procedure for doing that.

11.7 SLEEP ATTITUDE

COLLINS

The procedure was worked out fairly well. I don't recall any mention about deadbands. The ground, in all cases, wanted a 10-degree deadband. This was something they asked for in real time. I think it would have saved some chatter over the radio had all this been worked out and put into the flight plan. I needed the control mode and the four or five DSKY operations that are necessary to achieve a 10-degree deadband. Had they been printed in the flight plan, I think that would have helped.

11.8 PHOTOGRAPHY

COLLINS

I thought photography worked out well when I was in there by myself. The amount of time I devoted to photography was somewhat limited by the fact that I was doing P22 each and every pass. P22 was not compatible with good

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COLLINS
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photography. I probably would have spent more time taking pictures had it not been for the question of the LM landing location and the need for the additional P22's. I did use the intervalometer. I'll have to wait and see how those pictures came out. I feel the command module should carry plenty of film, and I think the key to getting some good pictures from the command module is having the luxury of being able to expose lots of film without worrying about running out of film.

11.10 MONITORING LUNAR ACTIVITY

COLLINS

There was some difficulty with the ground S-band relay. The preflight agreement was that all my transmissions would be relayed to the LM, and all LM transmissions would be relayed to me unless that mode of operation, because of systems failures or other problems, became too cluttered. At this time, the ground was free to amputate that relay mode. In flight, it did not work out that way. The relay was rarely enabled. I gather that this was because there was a ground switching problem. I would have preferred to be receiving continuous S-band relay from the LM, and I felt somewhat cut out of the loop, although it was not a safety problem. I felt out of the loop during the extended periods of time when the relay was not in effect.

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11.11 VISUAL MONITORING (MONOCULAR OR SEXTANT)

COLLINS

I did not use the monocular because I did not have the monocular. It went to the surface with the LM. I don't believe it would have been of any use in looking for the LM. The sextant is a more powerful and steadier instrument. It was not possible for me to find the LM on the surface with the sextant.

11.12 CO₂ CANISTER CHANGING

COLLINS

CO₂ canister changing was the same as when three people are in the spacecraft.

11.13 MANEUVERING TO SUPPORT LIFT-OFF

COLLINS

Maneuvering to support lift-off was worked out well preflight, and I followed it that way. I couldn't see the LM, but I did nonetheless go through the motions of maintaining the proper attitudes so that my radar transponder would be available in case the LM wanted to lock on. The CSM solo operations were fine. I was at ease about going to sleep and leaving the command module unattended. That didn't bother me at all. I would have guessed preflight that it might have, and it might have if I had had some failures prior to this time.

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12.0 LIFT-OFF, RENDEZVOUS, AND DOCKING

ARMSTRONG Feed water measurement was performed and the numbers were passed to the ground. I don't remember what they were. First, we zeroed the scale and then with the empty bag on, we took the bag off and reported the RCU weight, with the RCU and not the bag on. Then, we put the water in the bag and reported that weight. That's about a full bag of water.

ALDRIN Throughout all of this, I didn't have a real high confidence level of the accuracy of what we were doing.

ARMSTRONG One full bag of feed water is a lot.

ALDRIN I would think that a volume measurement might be just as accurate.

ARMSTRONG A volume measurement was the initial plan. That was discarded based on its accuracy.

ALDRIN The ground had concluded that the water level was lower in my PLSS. It would have seemed to me that that would have been the one to measure, but that wasn't the idea from the beginning. Since they had some indications that consumption was higher on mine, it would have been better to verify that one. We'll see what we get on that.

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ALDRIN
(CONT'D)

We were given an update on consumables, and we have already talked about the sleep period. They were looking at your BIOMED during the rest periods. As far as I know, we got up just about on schedule and started our activities. It might have been a good bit ahead of schedule, maybe a half an hour or something like that. To try and identify just what our position was, the ground wanted us to go through a P22 radar track of the command module. We had done this once, maybe twice, in the simulator, and on the surface, it looked like a fairly involved task. Once having run through it in the simulator, it's fairly straightforward. It turned out to be quite a simple operation. Before doing this, we configured circuit breakers and went through a DSKY computer check. I'm not sure why it was felt we needed to do this. These were notes as to how we were to handle a P22, option 1, no update. If we got a 503 alarm, we were to key in a proceed and leave the tape meter in altitude/altitude rate so it wouldn't drive into the stops — if it were on range and range rate. It would have been much easier to do a VERB 95 before starting it, because that's evidently what they meant. We went through an LGC self-test and brought the AGS back on line and then proceeded into the P57. I might point out a few things on the previous day's P57. The yaw left tended to move the one

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ALDRIN
(CONT'D)

star I wanted to use, Capella, out of the right rear detent. The Sun was in the rear detent and generally obscured it, even though it was not visible in the detent. Its light level was sufficiently high so that no stars could be seen in the rear detent. The Earth was in the forward detent, and due to the yaw left, it was also in the right detent.

12.1 APS LIFT-OFF

ALDRIN

We had another update from the ground instructing us not to go to AGS in the event that the LM engine didn't ignite and not to make a manual start. We agreed that we would wait a REV. Everything worked according to the checklist. We just emphasized that we did use the lunar align mode in the AGS and did not align the AGS to the PGNS, so it lifted off with its own reference system. It did have a PGNS state vector instead of the manual one that we could have given it in the LM slot.

Lift-off, or at ignition, we waited until the last 2 or 3 seconds, or almost simultaneously, Neil depressed the abort stage and threw the engine arm switch to ascent and I proceeded on the computer.

It might have been a second after the T-zero that any motion was detected. There was, as I recall, an appreciable

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ALDRIN
(CONT'D)

bang of the PYRO's and a fair amount of debris that was tossed out at the same time that we did detect first motion. It was a fairly smooth onset of lifting force. There wasn't any jolt to it. Yaw started gradually; it was not abrupt either in starting or ending. As a matter of fact, I really didn't notice it. I was looking more at some of the gages and the altitude rate, both in the PGNS and the AGS. It seemed to take quite a while before we accumulated 40 or 50 feet per second.

The pitch maneuver, as seen from inside the cockpit, was not in any way violent or very rapid as we were expecting. We seemed to have a good altitude margin looking down on the surface. It wasn't something that you'd describe as a particularly scary maneuver. I felt that we had adequate altitude rate at the time for that type of a maneuver. Right after the pitchover, I could still look out to the side and see the horizon. We could verify out the window what our pitch angle was.

12.4 VELOCITY AND ALTITUDE

ARMSTRONG

Velocity, altitude, altitude rate, and attitudes were consistent with the ascent table that we were monitoring. AGS and PGNS were consistent in attitude as frequent crosschecks on the attitude indicators showed and also in altitude rate,

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which was being read off the DEDA and compared with the PGNS value of H-dot.

ALDRIN

A couple of years ago, we had a simulation rigged up that tended to give us the sensations in the cockpit that you were liable to experience during LM ascent. We did this in the DCPS and they rotated us back and forth. Based upon this and many ascent simulations in the simulator, watching the rate needles pop back and forth, and the arrow needles wipe back and forth, I expected quite a roller coaster ride of whipping back and forth. Nothing could have been further from the way it actually turned out. It was a very smooth wallowing type of an ascent with far less excursions. Maybe the total rates were approximately the same, but the physical effort of them was not at all objectionable.

ARMSTRONG

The rates and attitude errors and attitude changes were consistent with the simulations. The physiological effect of these was much more akin to the description presented by the Apollo 10 crew of their ascent engine burn. It was very pleasant. It had a Dutch roll mode and relatively low frequency. It was not at all distracting toward your ability to monitor the ascent quantities that were significant. It was a very pleasant and unusual trajectory.

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ALDRIN

It was quite easy to look out the window and pick up craters as we approached them. We were keyed to look for the Cat's Paw or anything in the close vicinity to the landing site. I did see several craters, none of which I could positively identify as being the Cat's Paw or in that immediate vicinity. The track looked good as we came up and went by Ritter and approached the crater Schmidt.

Communications were excellent throughout the lift-off. We had backup S-band angles at 3 minutes. We didn't need to change any of those. We did accomplish everything in the checklist. The balance couple came off; we were called on the START button at a minute or so after lift-off.

Changed the film frame rate to at about 3 minutes from 12 frames a second to 6 frames a second. Throughout the remainder of the trajectory, I monitored the targeting quantities in NOUN 76, looked at the countdown time in NOUN 77, then picked up the DELTA-V to go in NOUN 85, and crosschecked it back with V_I to compare it with the trajectory. The numbers agreed very closely in H-dot and V_I . The altitude looked like it was coming right in on the targeted values, and the AGS agreed quite closely. The V to go, in address 50, did differ a good bit from what I was reading in NOUN 85. However, the AGS gave slightly

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different targeting. Its targeting is done on a different computation cycle, and I attributed the differences to that. The RCS quantity looked good, and the ascent feed seemed to be operating quite well. To avoid any rush approaching insertion, I elected to open the shutoff valves at about 700 to 600 ft/sec to go. I opened them one at a time, turned off the ascent feed, and closed the cross feed. As we approached 50 ft/sec to go, we still had good pressure in both ascent tanks. Of course, that was one thing we were looking at right up to lift-off to make sure we were feeding on both tanks. I think we inserted with 700 or 800 psi in both helium tanks. Approaching 50 ft/sec to go, we disarmed the engine and it was an AUTO cut-off.

ARMSTRONG

I think the overburn was about 2 ft/sec, and we nulled those.

ALDRIN

There was a certain amount of bounce to them, but since we didn't have anything over 1 or 2 in Z-component, we were able to get the X-component down to near zero, I think 0.1 or 0.2. The out-of-plane residual was small, in the order of 1, but not over 2. The AGS showed about 8 ft/sec out of plane, and it was, as I mentioned, operating on an independent alignment. VERB 82, as I recall,

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ALDRIN
(CONT'D)

showed something like a 47-mile apogee. We didn't have the radar to confirm the insertion, but MSFN was quick then to give us a good orbit. The AGS agreed very closely with the PGNS.

We got our range rate from the CSM.

ARMSTRONG

It was a satisfactory range rate.

12.5 ATTITUDE

ALDRIN

We got the attitude hold and balance couple on. I don't think we reset abort stage and engine stop immediately. We held off on those, disabled the TTCA's, and designated the radar down out of the field of view in preparation for the alignment. We configured the switches, stopped the camera, and progressed on with aligning the platform.

12.6 PGNS AND AGS

ARMSTRONG

The initial platform alignment planned use of Acrux and Antares as the stars, knowing that Acrux, based on our simulations, would be close to the horizon. I had an alternate in case it was too bright down there. When I AUTO maneuvered to Acrux, it was below the horizon and I couldn't see it, so I chose the first alternate, Atria and Altair. I AUTO'ed, so I went out of the program. I re-entered P52, going to star 34, Atria, AUTO maneuvered to

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the point, and it wasn't in the field of view either. Both of those stars had been in the field of view in all simulations. We terminated the program and reentered at Antares, I think. Is that right?

ALDRIN

37 and 34 are what I have.

ARMSTRONG

We reentered at Nunki, which we knew would be in the field of view. While I was getting marks on Nunki, I had Buzz look up something that might fit with Nunki to be a good second star, and I guess you came up with Atria.

ALDRIN

Yes. It was up in the field of view at that time.

ARMSTRONG

By this time, of course, the stars were rising at a rapid clip, and we could go back to Atria and be quite sure it was in the field of view.

SPEAKER

Which one did you try first?

ALDRIN

Acrux. That wasn't in, and neither was Antares.

ARMSTRONG

Neither was Atria.

No. We came back at Atria and got it, and the horizon was in the field of view during the mark. But we had satisfactory marks. We got all zeros on our star angle

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difference and very small torquing angle, indicating that our graph, our prelaunch alignment, was quite good.

ALDRIN

I think the largest one was in roll; and, of course, that doesn't affect the insertion as much. The most critical one is the pitch and that had 00064. The one that intrigued me was yaw (which will affect the out-of-plane insertion), and that had 406. The yaw that we had before that was based solely upon the star alignment that we used before lift-off. It went with the gravity, so it indicated that we had a very good azimuth alignment on the surface. The gravity was certainly adequate to do the job.

12.7 RENDEZVOUS NAVIGATION

ARMSTRONG

It was our intent to pick stars here that would be in the field of view and require a minimum amount of maneuvering and time to get through the alignment and would end up back in plane so that we would be in a place where we could turn the radar on, designate the acquisition, and start getting marks so that we would have a good solution for CSI. Somehow or other, all this planning didn't work out on those stars. Why our simulations did not correctly place those stars relative to the horizon, I don't know. They didn't, so we wasted a little time and a little fuel.

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ALDRIN

Even with these problems, we did quite well because we finished about 28 - 27 minutes before CSI and were able to proceed with getting the radar to lock on. That was accomplished without any difficulty. We got one VERB 1 NOUN 49 that we accepted. Before entering the program, we had VERB 95 then loaded to W-matrix. The enable updates - only one of them (the first) failed to pass the test, but it was significantly small, so we proceeded on it. While Neil was doing the alignment, I queried the AGS to see what it thought of the insertion and what it thought the CSI maneuver would be. It came up, just based on the insertion vector, with 15.5 DELTA-H and 51.3 ft/sec.

12.10 ASCENT CAMERA

ALDRIN

The camera was set up with settings as in the checklist, and inserted (pasted) into the checklist at TIG minus 2 was a notation of camera on. At that point, since we were starting at 12 frames per second, it was too early to bring the camera on. I would estimate something on the order of 30 to 40 seconds into the ascent before the camera was turned on.

In looking down at the time of the pitchover, I could see radiating out many, many particles of Kapton and pieces of thermal coating from the descent stage. It seemed almost

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to be going out with a slow-motion type view. It didn't seem to be dropping much in the near vicinity of the LM. I'm sure many of them were. They seemed to be going enormous distances from the initial PYRO firing and the ascent engine impinging upon the top of the descent stage.

ARMSTRONG

At the completion of the pitchover, you could easily detect visually that a strong positive outward radial rate had been established. There was no concern about attitude or falling back toward the Moon. I observed one sizable piece of the spacecraft flying along below us for a very long period of time after lift-off. I saw it hit the ground below us somewhere between 1 and 2 minutes into the trajectory.

ALDRIN

It's very difficult to conceive of such lightweight particles like that just taking off without any resistance at all. It's easy to think back and say that they would do that. But it just seems so unnatural for such flimsy particles to keep moving at this constant velocity radially outward in every direction that I could see out the front window. I don't recall seeing any impact with the ground, but there were sizable pieces.

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12.13 UPDATES FOR CSI

ALDRIN The ground gave us an update of 51.5 ft/sec for CSI with a 1 ft/sec out of plane. I have the values logged down here for what the PGNS came up with, and it eventually settled down on 51.5, also. Mike's solution agreed with the AGS at 51.3, and we elected to burn our solution without any out-of-plane component.

ARMSTRONG I was just amazed that we had four solutions within 0.2 ft/sec for CSI. That never happened before.

12.15 RCS/CSI BURN

ALDRIN I might point out two reasons why we didn't get a backup chart solution. One of them was the alignment. It took a little more time. I think we could have gotten a range rate at 28 and still gotten a good solution; however, the range rate that we were reading at that point was about 51 ft/sec. This was less than the values that were acceptable for the chart. In other words, it exceeded the limits for the rendezvous charts, and since we did end up with a 15-mile DELTA-H and had a good nominal insertion, the only thing I can attribute it to is the command module not being in a circular orbit having enough eccentricity to perturb the R-dot from what it should have been. I think this is another indication of where a late trajectory change was

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not completely analyzed to see what effects it had. Certainly, we had nominal conditions, but the trajectory change did result in range rate values that exceeded the ability of the chart to cope with them.

SPEAKER

How about the handling?

ALDRIN

The nulling of residuals with the thrusters, even with two-jet operations, produced a pronounced difference in translating with just the ascent stage. Each time you hit the thrust controller, the vehicle behaved as if somebody hit it with a sledge hammer, and you just moved. There is no doubt about the fact that the thrusters were firing.

ARMSTRONG

It's a very light, dancing vehicle, and this is true in attitude also. It's very unusual, and the fact that we got five zeros on that alignment, I think, is just a matter of being consistent with all the other good luck we had that day. It certainly was more difficult to do than the unstaged alignment where the vehicle was a lot steadier, and we didn't get results that were that good.

ALDRIN

It was sporty; there's no doubt about it. It appeared that with the automatic tracking and the wide deadband of the radar that it was not bouncing all over the sky. I guess I anticipated that it might have been even sportier

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than it turned out to be, even though it was a difficult job doing precise aligning with it. I think the 10 mission indicated that. They thought that they had a lightweight vehicle, but, of course, they had much more fuel on board than we did.

ARMSTRONG

We did not find as severe a reaction to operating in PGNS AUTO as had been earlier reported. I can't confirm just what their configuration was in terms of the DAP and vehicle inertias, but our combinations made the vehicle fly quite comfortably in PGNS AUTO. We used that mode more or less intermittently with PGNS pulse. We almost did all the manual flying in PGNS pulse, and the remainder of the time, we were in PGNS AUTO. Burns in PGNS attitude holds were generally done with VERB 77.

ALDRIN

That lightweight a vehicle did appear as though it was not an easy task to make either X- or Z-axis burns. Of course, all burns were Z-axis burns. To make them, and at the same time avoid having residuals of a fairly sizable number (at least less than 1 ft/sec) is quite difficult. We did end up with minus 0.2, plus 0.7, minus 0.1. The AGS agreed fairly close again, showing the greatest difference in Z, which I think is attributable to the rotation of the burn

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when loaded into the AGS. The radar stayed locked on throughout the maneuver.

We started updating right on schedule, changing the W-matrix to the flight plan values. We checked the numbers just before we changed it. I think we could recall them, if somebody wanted them. 1900, maybe something like 15.3 milliradians. Then we started to work on the plane change. What I did was make use of VERB 90 and ask it what out-of-plane condition it had right now. This saves a little bit of time in not having to load in numbers. We were coming up with things on the order of 1 mile out of plane and 2 or 3 ft/sec. The actual solutions that both vehicles came up with were: our first one was minus 3.2, Mike had minus 2.3; our final one was minus 2.9. As small as they were, we cancelled the plane change maneuver to get more tracking data.

12.18 RCS/CDH BURN

ALDRIN

At CDH, we took out time as computed by the CSI program for the CDH maneuver and voiced in the maneuver to Mike to put in his P76. When you're really getting precise, the question arises what to do with residuals on the order of a couple of tenths. Do you take advantage of them or ignore them? We chose to ignore these small amounts and

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not thrust. The exception was the out-of-plane condition, and we were handling that as a separate item anyway.

DELTA-H varied between CSI and CDH solutions anywhere from 15.3 to 15.7. In general, the CDH maneuver decreased in magnitude. Even on the ones we had in the CSI program, it came up with 19.3 ft/sec and settled down to 18, which I think is indicative of the noncircularity of Mike's orbit. We had no concrete evidence of that really. Our procedures had not called for finding what his orbit was. The ground never did tell us what his orbit was and what we ought to expect for CDH. I think we were kind of left on our own coming up for CDH as to what was an acceptable burn. The data card gives a nominal H-dot of 4 ft/sec. We had 18.

COLLINS

Four is for circular CSM orbit.

ALDRIN

Yes, and that's what you're supposed to have.

COLLINS

I didn't.

12.20 TARGETING PGNS AND AGS

ALDRIN

I had components here for the AGS maneuver: CDH 9.1, 2.4, and 14.6. As per the procedures loaded in the PGNS maneuver, the AGS was updated with the PGNS for CDH.

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12.21 UPDATING AGS WITH RR DATA

ALDRIN

After CDH, things seemed to be working so smoothly, and DELTA-H seemed to be so constant that I elected to start putting radar data into the AGS. This seemed to be accomplished without an undue time burden. I've got the data here that indicates what the AGS solution was for TPI with only AGS update going into it. I think this will be fairly interesting to some people. In other words, it solved for a TPI.

12.23 RCS/TPI

ALDRIN

We burned the PGNS at TPI and then I left the AGS residuals, which are a measure of the difference that it would have solved, and they were on the order of 2-1/2 to 3 ft/sec. Everybody zeroed in on about the same maneuver for the TPI. I guess in the LM you want to delay committing yourself, since you're picking the angle option, to saying exactly what time TPI is going to be until as late as possible. Unfortunately, this presents a burden on the CMP, because he's got the time option. He wants to know what time we're executing it. We gave him a time, and it changed by maybe 30 seconds.

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12.27 MIDCOURSE CORRECTIONS

ALDRIN

The first midcourse correction was less than 1 ft/sec. I think we gave the values to the CMP, and he put them in external targeting. The second midcourse correction was about 1-1/2 ft/sec. We burned them in components. I guess it's up to you on angular rates. We picked up range rates from that point on.

In a moment of confusion about this time, I observed a significant nonzero lateral deflection in my cross pointer, which I interpreted as being a lateral line-of-sight rate indicating some out-of-plane velocity. This was just a misinterpretation, however. I had to switch in landing radar computer rather than radar line-of-sight rate. So we were actually reading in either AGS or PGNS a version of out-of-plane velocity at that point. I can't explain why that was indicated to be a large number. There wasn't a real number. The line-of-sight rates were, in fact, very low. And as I remember, it was indicating something like 7 ft/sec.

ARMSTRONG

The whole thing from once we finished alignment was just a very leisurely running through of what we had done many times before. Where we were familiar with it was a relatively simple operation. Rendezvous with the PGNS is a

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piece of cake as long as everything's working. When you start getting PROGRAM ALARM's and radar won't go in, it gets pretty hairy. This happened during several SIM's. You start chasing yourself around the cockpit. But with things working fine, it's simple. It does require close coordination with the other vehicle to keep the flow of information going back and forth. The ground didn't bother us at all. They were watching what was going on, and they called up confirmation of our CDH solution.

12.31 BRAKING GATES

ARMSTRONG

Braking was pretty much on the braking schedule; no problems there. The line-of-sight rates were small and easily controlled. The line-of-sight rate indicator gave us proper indications of line-of-sight rates. The line-of-sight rate indicator does not work like the simulator in several areas. The most significant is when the radar antenna goes from a Sun line-of-site rating back to zero; it does not do it instantaneously as in the simulator. It takes about 5 seconds for the antenna to slow down for a stop for the needle to come to the peg back to zero. Both the sizes of the needle deflections and the rates that they deflect are not correctly simulated in the simulator.

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12.36 DOCKING

ARMSTRONG

We stopped braking phase at 50 to 100 feet, insured that both vehicles were in a docking configuration, and at this point, we ran into a problem that we wouldn't have anticipated preflight. Our procedure was for the LM to get into stationkeeping position 40 feet out in front of the command module plus X-axis, pitch over 90 degrees so that the X-axes are colinear, then yaw left 60 degrees so that we are in the docking attitude with the command module. It was obvious when we got to this point, if we pitched the LM over 90 degrees, we would be looking directly into the Sun. We knew that would be an unsatisfactory lighting condition for docking. So the alternative would be to roll the LM 60 degrees, pitch down, and then you'd be in the same attitude and would have prevented the Sun coming into the window. After arriving at that attitude, a discussion between the LM and the command module indicated that we weren't quite far enough, so I rolled a little farther, pitched over, and waited looking through the top window. We were asked to rotate a little farther by the command module to line up the docking aids and get the proper alignments. We complied and promptly maneuvered the vehicle directly in the gimbal lock. I wasn't aware of it because I was looking out the top window. No doubt,

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ARMSTRONG
(CONT'D)

we were firmly ensconced in gimbal lock. We had all the lights on, the DAP was not operating anymore, we had no control outputs, clearly no CDU outputs were being processed, so we just put it in AGS and completed the docking in AGS.

ALDRIN

And I don't think the AGS is a good system to dock in, or PGNS either.

ARMSTRONG

This was just a goof on our part. We never should have arrived at the conclusion from any series of maneuvers. However, that's how it happened. It wasn't significant in this case, but it certainly is never a desirable thing to do. There's nothing catastrophic about it here, but I'm sorry that somehow or other we hadn't studied the docking maneuver a little bit more carefully and recognized that there might be some attitude constraints in the maneuver that we hadn't considered.

ALDRIN

The few times that we'd done that previously we ended up approaching docking with the Sun more along the line of sight to the two vehicles. This was more our concern, arriving at the docking point a little bit late. If you arrive there a little late and the line-of-sight motion happens to be such, the Sun is going to be pretty close

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ALDRIN
(CONT'D)

to where the command module was. In this particular case, it was about 90 degrees away. After getting in that attitude (or getting docked), to have a PGNS operating, I aligned it to zero and went through the quick alignment procedure. I got the PGNS back in operation again and figured it was not a known REFSMMAT. There were no postdocking maneuvers planned by the LM, so to get both systems the same, I then aligned the AGS to the PGNS. Both of them lost their reference, but both of them were 00 and as far away from any future gimbal lock as they could be. That might have been a better way to operate anyway.

COLLINS

The rendezvous procedures from the command module viewpoint were about as well worked out, I thought, as they could be with the existing command module computer structure and with the degree of participation necessary by the CMP. I have always felt, and I still feel, that the system is designed in such a fashion that the CMP is too busy during the rendezvous procedure. Although I was able to keep up with the timeline quite well, I felt that I was devoting too large a percentage of my time to the job and that I really was poorly placed to

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(CONT'D)

cope with any systems problems or any other difficulties or abnormalities that might have come up. I don't propose any sweeping changes from mainline Apollo. It would be fruitless to do so, but I really think that for future vehicles the rendezvous should be something that is relatively straightforward, something which does not require literally hundreds of simulator hours to master the procedural aspects of. I think, as we get into these lunar-exploration flights, the crew is going to be forced to devote more and more of their attention to what they're going to do once they've arrived, not just to working out the procedures for how to arrive. I really think that. From the command module viewpoint, with one man inside the command module, I think the procedure should be simplified, and if that requires a greater degree of automation, then I think we ought to have more automation. I had a solo book which combined features of various other publications, the idea being I wouldn't have to chase around the cockpit; I would have everything under one cover. This concept worked well. I recommend it highly. The only funny I had during the rendezvous was the VHF ranging kept breaking lock. I had a good lockon during ascent just as I had during the simulations.

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COLLINS
(CONT'D)

I was surprised when, after insertion, VHF ranging broke lock. I did reacquire, but from then on, the thing broke lock 25 times during the course of the rendezvous. Sometimes, I could immediately reacquire with the reset switch on panel 9. Other times, it was not possible to reacquire. I would have to go VERB 88 ENTER to lock the VHF ranging data out of the computer, and then at some later interval, I would get a good reacquisition and do VERB 87 ENTER to allow that data to come back into the computer. It was possible for me to tell, after a little practice, whether I was going to get a good lock or not by listening to the tone during the lockup procedure. There are three tones, two of which are in the audible range. If it was going to be a good solid lock, the tones would be very clear and sharp just as they are in the simulator. If it was not going to be a good lock, if the lock was going to be unsuccessful, the tone sounded very scratchy and had a lot of static. After the third tone had completed its cycle, the numbers would appear very briefly on the EMS and then they would almost immediately go to zero, indicating the thing had broken lock. I used a technique of setting the mission timer in the lower equipment bay to the nominal LM

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lift-off time of 124 hours, 23 minutes and 25 seconds. At the instant the LM lifted off, I started that clock running. I kept two times; the LEB time was flight plan time. If I followed it, I could with a high degree of accuracy tell you where I should be in my procedures book. I left the MDC clock undisturbed, so that all the updates and communications with the ground could be done in true and correct time. It worked well for me. I practiced it in the SIM's. I was influenced by the fact that the digital event timers had a poor history of reliability and that the digital event timers in spacecraft 107 had been replaced once and further had little funnies in them during tests. If you trust the digital event timers to count down to burns, then probably my procedure is an unduly complicated one. On the other hand, it is workable. I found it an aid in running through this, despite the fact that we were a couple of minutes off nominal. I have some numbers on breaking lock. I first got lockon during the latter part of the ascent burn. It broke lock at 124 hours and 31 minutes, re-acquired immediately, and broke the second time at 124:34. It broke twice thereafter in rapid succession. I relayed my out-of-plane solutions to the LM. They

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COLLINS
(CONT'D)

were, after insertion, on the order of 1 ft/sec, and the LM Y-dot minus 1.0. I had my own Y-dot plus 1.4. CSI solutions compared fairly close with the LM and the ground solutions. I think Buzz has reported those numbers previously. I was in an orbit of 63.2 by 56.8, which could explain some of the up-down component in the CDH solution, as well as some R-dot peculiarity the LM experienced.

I had some eccentricity in your orbit after CSI. I had you 49.5 by 46.1. I think the combination of those two screwy orbits could explain lots of R-dot dispersions and up-down components.

ALDRIN

I asked the computer what time we were going to get to apogee, and it was only a couple of minutes off to CSI time.

ARMSTRONG

Yes, but you didn't know where his apolune was.

ALDRIN

That's right. Ninety degrees away.

COLLINS

I don't think it's worth our spending a lot of time here trying to hash out these numbers. I just mentioned them for the record. A plane change was not required during the burn. I still think that it's possible under some

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disperse circumstances to have a large plane change required following an ascent from the lunar surface. This plane change might have to be done by the command module using the SPS. This is something that had never had procedures worked out for it. I did invent a procedure. I don't think FOD liked it although they didn't have any better procedure. I would suggest that the FCOD come up with a procedure that MIT and FOD and the Center agree might be used to allow the command module to whip around and make an out-of-plane SPS burn. Now, the one that I invented was sort of sneaky. It took P52, the platform align program, and told P52 to align the platform to a landing site which arbitrarily was said to be 35 degrees north latitude. Of course, this is completely phony, but it cocked the platform off 35 degrees in roll, so that when you yaw out of plane either left or right, you'll go above the cherry or below the cherry, because the platform has been rolled out of the way. It worked well in the simulator. I don't know what the objection to it is. I had a little procedure drawn up, and it was included in the rendezvous book. If this is not a good procedure, then it should have been substituted

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COLLINS
(CONT'D)

for something better. You need to have in your hip pocket some quick way of whipping that command module around 90 degrees and burning SPS.

ALDRIN

You didn't want to do it by just taking it 45 and asking for a good preferred alignment?

COLLINS

But you have to get a new REFSMMAT from the ground and everything else.

ALDRIN

Another way, you load the burn in P30.

COLLINS

I see what you're saying.

ALDRIN

Then go into P40, find out what it is, set the REFSMMAT flag, and then go into it.

COLLINS

Yes. That's another way of doing it. You can do it that way as well. This P52 way was just quick and simple and dirty.

Another little funny I noticed (maybe it's something that I overlooked in my training) was after CSI when I went to P20. P20 would not track the LM; in fiddling around, I found that if I recycle the optics zero switch it would track the LM. Now, as a matter of practice, I had always left the LEB in optics manual and optics zero to

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zero. The reason you leave it that way is because of failure modes in the CDU's, which are shared with the thrust vector control if you're going to burn the SPS. In the simulator, when you get back down into the LEB, all you have to do is take that optics zero switch and throw it off, and P20 will immediately start tracking the LM.

ALDRIN

Did you have it in CMC?

COLLINS

Yes, CMC. But on two occasions it wouldn't do it. I found if I cycled the optics zero switch, it would track the LM. I don't understand this. It's as if there is a funny in that switch in regard to the optics power. When you first turn optics power on for P52, you have to cycle that switch back to zero for the program to be aware that it has been zero. Otherwise, you get into CDU difficulties. It's something similar to that. Anyhow, after CSI when I went to P20, the sextant would not track the LM until I had recycled the optics zero switch. How I knew to do that, I don't know. It was just trial and error.

VHF ranging broke lock again along about plane-change time. It broke lock again at 126 hours. We've already discussed the CDH solutions.

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I had hoped to get some sextant marks immediately after CDH, but prior to going into P34 this was questionable because of the position of the Sun. I thought that I could probably get three or four marks before Sun shafting prevented it. I was wrong. I couldn't get any marks at all. After CDH, I was able to get VHF marks only for a little while.

In the meantime, I went into P34 and I had a very slow COMP cycle the first time through on P34. Up until this time, the AUTO optics had been doing a smooth job of tracking the LM. I noticed that this smoothness disappeared a few minutes prior to the TPI. It became quite jerky. I made a little note here - the LM tracking jerky in sextant, and DAP excessive pitch thruster firings. It seemed like there was a little flurry of pitch thrusters firings along about this point as well, which I don't have any explanation for.

Everything progressed normally through TPI. It was along about midcourse time when I first saw the LM coming up from below. It looked like the doggone LM was riding on rails. There was absolutely no line-of-sight rate that I could see. It really looked great to see the LM coming up from the surface. For the first time, I had

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the feeling that that son of a gun was really going to get there in one piece.

Midcourses were very small. Braking was done entirely by the LM. I was completely passive, and that's all I have to say about the rendezvous.

Docking we did in CMC, AUTO, narrow deadband under DAP control. Neil made the crude alignments to get the correct side of the LM pointed toward the COAS. Then I made the final adjustments. I estimated that I contacted the LM just about exactly dead center and at a slow-but-adequate closing velocity. I would guess slightly in excess of 0.1 ft/sec. Despite this fact, I couldn't tell the instant of contact. The empty ascent stage is light enough relative to the command module that when the two vehicles touch, it's just sort of like pushing into a piece of paper. The LM recoiled enough that they could feel it in the LM, but I couldn't really feel it in the command module. I thought I was getting there, and I thought I was getting there, and I finally was fairly sure I had contact. I looked up for the third or fourth time, and I did have two barberpoles indicating that the capture latches had made. At this time, I looked out the window, and the situation appeared static. I threw the

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(CONT'D)

switch from AUTO to FREE, so that I was in CMC, FREE.

I looked out the window again — this was all going pretty fast now — I would say this was 3 seconds after contact. The situation looked like it had previously; that is, the two vehicles were statically joined together with no motion. At that time, I fired the bottle. No sooner did the bottle fire than a yaw gyration started between the two vehicles. I'm not sure whether it was a result of the retract cycle beginning or whether it was a result of the LM firing thrusters toward me. At that time, this static situation became very dynamic, and a fairly large yaw excursion took place. I would say that relative to the LM I rapidly went to about a 15-degree yaw right angle. I put the CMC, FREE switch back to CMC, AUTO. This enabled the hand controller in rate command and minimum deadband. I made manual inputs to yaw back over towards the centerline, and there were a couple of other oscillations enroute. I can remember thinking, "I don't think we're going to get a successful hard dock this time. I'm probably going to have to let the LM go and try again." About that time, the docking latches fired, and we were hard docked. I would guess that the time interval from firing the bottle to hard dock was about 6 to 8 seconds. This is probably

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a pretty normal retract time. Things were happening fairly rapidly, and the oscillations had built up almost exactly at the time I fired the bottle which was primary 2.

ARMSTRONG

I can add a few comments here from the other side. At the time we felt the contact — which really was difficult to feel — it was a very low bump sound, or touch in the tunnel; we fired plus X RCS in the LM as per the preflight plan. Shortly thereafter, we also observed significant attitude oscillation. I guess it would be primarily right roll as observed in the LM. We were in AGS RATE COMMAND minimum deadband and, in addition, plus X. As soon as the attitude deviation started, I left the plus X off and called for Buzz to give me MAX deadband in the thrusters so we wouldn't be firing a lot of attitude thrusters. Then I took control and manually maneuvered the vehicle back toward colinear status. About that time, it snapped us in there and locked the latches.

COLLINS

I didn't like the idea of these two vehicles being joined together just by these two little capture latches. I was in the habit of firing the bottle the first time it appeared; the two vehicles had been joined together and the situation was static. I never gave these oscillations

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COLLINS
(CONT'D)

a fair chance to develop. Maybe a better thing to do is delay firing the bottle until you are sure the oscillations are not going to develop. Although it was sort of alarming there for a second or two, this way did work and it was within the envelope. I'm not sure if I had it to do over again that I would do differently. It depends on what caused the oscillations to get started. It could be the thruster firing of the LM or it could be some other cause. If it's the thruster firing of the LM, then you ought to delete the thruster firing on the LM. I'm not really sure you need that thruster firing on the LM.

ALDRIN

I'm not either ...

COLLINS

If it's some other cause, then the thruster firing of the IM is probably not a bad thing.

ALDRIN

It should tend to give some stabilizing effect to the IM. You'd like to have some control system that's holding the IM fairly close to where you want it to be. I think automatic is probably able to catch sooner than manual. Because you're looking up this way, it's pretty darn hard to maintain a close position. That argument says that you ought to be in some kind of automatic rate command system.

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ARMSTRONG

I think we have to admit that this was one area, in retrospect, that we gave less thought to than it probably deserves. During simulations, none of our simulators is able to duplicate this kind of dynamics. We saw some film that had been taken of a McDonald study. We saw these and observed what their recommendations were. That's what was incorporated in our docking plan.

That really was devised to get the capture latches in. I really suspect that everything we experienced happened after the capture latches were engaged. The results of that study really weren't pertinent to this particular phenomenon. We hadn't experienced any trouble at all on your previous docking. That was just as smooth as glass.

ALDRIN

It seems to me that it's not too good a mode to be working in. You're tempted, if the thing starts to move on you, to touch the stick. As soon as you do that, you have now reset a new attitude that may not be what the combined systems are going to be happy with; and if it's not, it's going to fire.

ARMSTRONG

That's right. I'm not sure that a lot of thought on our part in this area would have made the situation any better.

COLLINS

No. That's right.

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ALDRIN

I don't think we got a tremendous amount of guidance out of the AOH or anybody. It seemed to be, however you want to do it. You can do it this way or that way. They are both acceptable means in the AOH. It seemed to me there were two ways to be acceptable, and this was with primary guidance control. We didn't have primary guidance control because of the gimbal lock problem. It seemed to me that the book treated that subject a little lightly. Wasn't it written for IM active?

ARMSTRONG

Yes.

COLLINS

We gave the subject very little training time, but had we given it a lot of training time, I'm not sure we could have come to any different conclusions.

ARMSTRONG

It did bite us a little bit.

ALDRIN

It's worthy of concern because if you do prang something the consequences are time consuming and nasty to have to go through.

ARMSTRONG

This one got to us and, for one reason or another, we didn't understand it well enough. I suggest that the next crew spend a little more time than we did in this area and try to improve on the procedures.

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ALDRIN All other dockings were done in PGNS.

COLLINS This was the same procedure from the command module. The only difference was that the IM ascent stage was considerably lighter.

ARMSTRONG The IM control configuration was different.

COLLINS Yes, I meant from the dynamics of the command module viewpoint. I had the feeling that going to FREE under these circumstances was a mistake.

ALDRIN You don't have a good choice of deadbands. Half a degree seems to me to be too tight for this operation, and 5 degrees is much too loose.

COLLINS Flag it as a problem. I don't have a solution.

12.38 POST DOCKING CHECKS AND PRESSURIZATION

COLLINS When I went into the tunnel this time, I had that same strong odor of burnt material. Again, I checked everything very closely and couldn't find anything wrong. All the decals and checklists were well worked out for the probe and drogue. I was glad to see it work. I never had much confidence that our tunnel was going to work as advertised, but it sure did. I was very happy to see the

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(CONT'D)

tunnel, the probe, the drogue, and all that stuff part company and go along with the LM.

12.39 TUNNEL OPERATIONS

COLLINS

We went through an extra operation, and this is something that we never practiced jointly. It was my intent to take the probe out, the drogue out, and put those two items inside the command module. I guess it was your intent to take them out from your side and put them inside the LM. I just happened to beat you to it. It really wasn't very efficient the way I did it.

ALDRIN

I thought you were going to do it.

ARMSTRONG

I had it in my mind that I was going to do it.

COLLINS

The flight plan didn't mention it. It sort of implied that you guys were going to do it, because it said to remove and stow tunnel hatch, and then it said to notify LM crew they could open their hatch. It didn't mention the probe and drogue. When I came to that, I thought they just left that out of the flight plan. I said, "Stand by one." Then I got the probe and drogue out and stowed them onboard in the command module. This was an

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extra operation because subsequently they had to be transferred to the LM. This is another area where we couldn't say that we had smooth coordination. I knew how to do my end, and the LM knew how to do their end; but we hadn't sat down and discussed who was going to do precisely what.

12.40 TRANSFER OF LM EQUIPMENT AND FILM

ARMSTRONG

The equipment transfer and cleaning back contamination procedures were done essentially in the manner that was planned. We had a couple of small differences. We decided we wanted to bring the LEVA bags, and the LEVA's, and the EVA gloves back with us for postflight examination. We brought the whole ISA, interim stowage assembly, with all its transfer gear into the command module. The intent was to unload that, restow it in the command module, and then take the ISA back into the LM. We didn't do that. We brought the ISA back in the command module with us. That's a 1-pound item or something. We were able to get through that procedure about on the planned timeline.

ALDRIN

As a matter of fact, they were thinking about moving up TEI.

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ARMSTRONG Well, as it turned out, our LM jettison time could not have been moved forward a REV.

ALDRIN Because of attitude.

ARMSTRONG We couldn't have made it really.

ALDRIN Because of the attitude?

ARMSTRONG No, we just couldn't have gotten through in time.

COLLINS We were an hour, maybe an hour and a half, ahead of time.

12.41 VACUUMING EQUIPMENT

ARMSTRONG I was concerned that it might take us a lot of time to clean the LM, and I was also concerned that we would have a lot of free-floating lunar dust in the cockpit going back to insertion. We really wondered at engine cut-off whether we wouldn't be completely engulfed in soot and be unable to take our helmets off for the alignments. However, there wasn't much dust, and we couldn't figure that out because - -

ALDRIN The stuff seemed to stick to things and stay there.

ARMSTRONG I thought we'd tramped a lot of it with us, but it didn't bother us.

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ALDRIN I wiped it up with my suit on the floor.

ARMSTRONG We did clean with the vacuum cleaner as best we could. That vacuum cleaner has a very low suction, and more time was required than we planned to do the cleaning job. We were afraid it wouldn't be done to the degree of completeness that we had hoped for.

We were able to clean the suits satisfactorily with a scrubbing motion. However, there wasn't a large amount of free contaminate in the LM. We wore the suits back into the command module and restowed them in the L-shaped bag after a drying-out period. The LCG's were also stowed with the suits in the L-shaped bag. The suits were relatively clean, but they had a lot of residual smudges on them.

ALDRIN There was no hope of getting that off.

12.43 STOWAGE OF SRC's

ALDRIN The bags for the rock box, I think, could have some better labeling on them. You want the box to be mounted correctly in the command module so that one g or the g forces of entry will push the material down towards the bottom of the box instead of the top. But nothing really tells you how you put the box inside the bag. You can

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ALDRIN
(CONT'D)

put it either way. We learned by the way the lettering was, you had to put the bag on the box upside down to the way you normally think. It would help if the zipper went around the bottom instead of around the top; so I think that some more labeling would be in order just to make sure that no one puts the box in the bag upside down. I don't know how critical that is, but it's worth noting.

ARMSTRONG

Stowage was planned, plus we had a large temporary stowage bag completely filled with command module trash, food wrappers, and so on, which was transferred to the LM to clean up the command module volume.

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13.0 LUNAR MODULE JETTISON THROUGH TEI

13.1 LM JETTISON

ARMSTRONG LM jettison went as planned.

ALDRIN Was there ever any intentions to track the LM after jettison.

COLLINS No. That was never even discussed.

ALDRIN I don't understand why we left it in VHF ranging mode and left the track light on.

COLLINS I have no idea. We never had a DTO on it, or to my knowledge, it was never even discussed.

ARMSTRONG The separation was slow and majestic; we were able to follow it visually for a long time.

COLLINS The LM held its attitude extremely well. I don't know what mode you left it in, but I thought when the explosive charge fired, it would sort of start going ass over tea kettle. It must have been in some good attitude hold mode, wasn't it?

ARMSTRONG We could watch the jets fire to hold attitude as it went away.

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ALDRIN

It was in MAX deadband, AGS ATT hold. It seemed to me that, right at the time of separation, as the LM moved away, I could see some cracks that had developed in the outer thin skin of the top part of the LM in the gray material that forms an area around the docking cone. However, according to the ground it held pressure. I couldn't see any other damage that had been caused by blowing the tunnel.

COLLINS

The only comment that I had is that the separation burn was something that MPAD had changed their minds about a time or two. Originally, it was going to be 1 ft/sec horizontal retrograde. Then for some reason, they wanted it 45 degrees up from horizontal, and they wanted 1 ft/sec retrograde component or a total burn of 1.4 ft/sec. I don't have any preference one way or the other. It just seems like that's a fairly simple thing, and they ought to get their desire worked out early in the game and not have that be a late, last minute change, because it just makes for last minute conversations on unimportant things.

13.2 DOFFING AND BAGGING HELMETS AND GLOVES

ALDRIN

We didn't put the helmets in the LEVA's did we?

ARMSTRONG

No.

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ALDRIN Looking back on it, I think it would have eased the stowage problem in the command module.

ARMSTRONG Yes, but there was a reason for that, and that's that the LEVA's and the EVA gloves were both awfully smudgy. The choice there was to leave them sealed up in the LEVA bags rather than to get that soot out into the command module.

13.4 ORBITAL NAVIGATION

COLLINS The activities prior to TEI were leisurely. The updates were passed up in good time, we passed our sextant star check. In general, the usual sequence of P30 and P40 is one that has been well worked out and TEI had no surprises up until TIG time.

13.9 TARGET-OF-OPPORTUNITY PHOTOGRAPHY

COLLINS Well, we took a few photographs prior to TEI, but essentially we spent the time preparing for the burn. We didn't do any television prior to TEI.

13.12 TEI OVERBURN CRITERIA

COLLINS Those criteria were ones that had been hammered out for a long time. We didn't have any argument with them. Essentially it was a 2-second overburn, if confirmed by EMS reading of minus 40 ft/sec. We came close to shutting

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COLLINS
(CONT'D)

the burn down manually — I'll get into that a little bit later.

13.15 PREPARATION FOR TEI

COLLINS

At TIG, this was the first burn with CSM only. I had my rate needles on 5/1 and I did that because I think it's a good mode to be in if you're worried about any sort of abnormal dynamics. They're much more readily apparent on the sensitive scale.

13.16 SPS/TEI BURN AND ECO

COLLINS

AT TIG, I noticed more rate-needle activity that I had seen in previous burns. I had a start transient of probably 0.4-ft/sec activity on the rate needles in both pitch and yaw; there was very little attitude deviation. It was just a fairly rapid oscillation of both the gimbal position indicators and the rate needles and it damped itself down I'd say within the first 10 or 15 seconds of the burn. In roll, the vehicle was deadbanding. Instead of plus or minus 5 degrees, it appeared on my attitude indicator to be more like plus or minus 8-degree roll deadband and it was banging against the roll stops fairly crisply. It would cruise over, hit deadband and jets would fire, and it would go back the other way.

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COLLINS
(CONT'D)

This roll deadbanding was quite obvious during this burn as opposed to the other burns. I think all these indications are normal. They were just somewhat exaggerated during the first 20 seconds of the burn compared to the more damped case of having the LM attached. The EMS counter moves out pretty swiftly and it was difficult for me to estimate exactly when I might have minus 40 on the counter. The I_{sp} of the engine must have decreased or something; at any rate, the burn duration was longer than predicted and when burn time plus 2 seconds had elapsed, I had thought that I would have minus 40 on the EMS counter by the time I could get the thing shut down. There was some doubt in my mind as to whether it was shutting itself down automatically or not; so, at burn time plus 2 seconds and some small fraction, I turned both EMS DELTA-V — or both DELTA-V — normal switches off. I think just a fraction of a second prior to this we got a good automatic shutdown. At any rate, our residuals were very small; so either we got a good automatic shutdown followed immediately by my turning the switches off or else I shut the thing down manually and was just extremely lucky in that it coincided with the PGNS residuals. For some reason, that burn duration was a little bit longer than I would have expected. LOI, you remember,

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(CONT'D)

was shorter than we had predicted and this was the next burn to follow LOI, so I was sort of surprised that it did take longer than normal.

ALDRIN

The PUGS was a little bit unpredictable based upon performance during LOI. The fact that I couldn't catch up with the increase and it got ahead by about 0.4 or 0.5, something like that, plus the preflight briefing that that would be the case was why I left the switch in INCREASE. We lit off and got through the initial guidance and I looked at the meter and it was showing down in DECREASE, which struck me as not being what it should do. I expected it to be in INCREASE, but I thought "Well, maybe this is a characteristic such that early in the burn it does this sort of thing." So I left the switch where it was to try to catch up. I guess in the meantime that the two numbers — where one had been bigger than the other — had changed positions, in addition to the fact that when it says INCREASE, you throw it in the INCREASE direction. It's not at all obvious during a burn if one is a little bigger than the other. You're not sure whether the needle is believable or not, so I left it in INCREASE and it seemed as though it was getting farther apart and the needle was staying down; so contrary to what we had been led to believe, I put the thing down to DECREASE just to

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ALDRIN
(CONT'D)

see what was going to happen. Sure enough, it stopped the divergence of the two numbers. We didn't have a long enough burn for it to get right to zero, but it was within 0.2. Anyway, it was a little different than what we had expected. I guess, if you really want to play that game, you might need to write some cues or something on there so you don't misinterpret anything. It worked out well. But it was unusual and that might have something to do with burn time.

ARMSTRONG

We tried something different on this flight. The ground computed a postburn state vector, a predicted postburn state vector and put it in the LM slot. After the end of the burn, we could call up VERB 83 and get an R and R-dot from our state vector over to the predicted state vector. It came out real close — 0.7 mile and 0.8 ft/sec — indicating (it's kind of another double check) that we really did get the burn that we thought we were going to get. That's not really any kind of requirement if everything works. It is a nice kind of thing if you have an SPS problem or if you take over with the SCS in the middle of the burn when your computer is working okay, but the guidance isn't working. You can use that vector in your hip pocket to find out how good of a switchover you did and how close your SCS burn came out.

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14.0 TRANSLUNAR COAST

14.1 SYSTEMS VERIFICATION FOR COAST

COLLINS All the systems were GO; there wasn't anything to do.

14.2 NAVIGATION, NAVIGATIONAL SIGHTINGS, AND OPTICS

COLLINS We didn't do any onboard navigation. Our flight plan called for doing it only in the event of COMM failures. The optics worked normally on the way home.

14.3 EVAPORATORS: ACTIVATION AND DEACTIVATION

COLLINS We did not activate either the primary or the secondary evaporators until just prior to entry; so, during trans-earth coast, those were not in the system.

14.4 PASSIVE THERMAL CONTROL

COLLINS Passive thermal control three modes — we didn't have three modes, we just had the one mode. We always rolled G&N control at 0.3 deg/sec; that procedure we've already talked about. There were no differences in transearth, although the geometry of the vehicles was a lot different and I thought that the command module by itself would go unstable more quickly. Neil thought it would not, and he was right. It was very stable on the way back, just as it was on the way out.

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ALDRIN The LMP would have preferred pointing north. However, there was an added advantage in that we got to look at the Magellanic clouds by PTC-ing at 270.

ARMSTRONG To look at the earth, to look north, you had to get upside down.

COLLINS Yes, we went out in 090 pitch angle and came back 270 pitch angle. It's "macht nichts" to me; I don't care one way or the other.

14.5 EXCESSIVE MOISTURE ON TUNNEL HATCH AREA

COLLINS There was a little tiny bit of moisture up in there at various times. On the way home, there was less than there had been earlier. The last time I checked was at 180 hours or thereabouts.

ALDRIN You thought it was less? I don't remember much moisture at all.

ARMSTRONG I thought it was more on the way home.

ALDRIN I did too. We made use of the ECS hoses.

COLLINS Yes, I put the hoses up there and there's one comment in here. Here it is - "180 hours, dry as a bone."

ALDRIN That was after we put the hoses up there.

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COLLINS Prior to that, there was a little bit of moisture up there and I did wipe it off with a towel sometime after TEI.

ARMSTRONG I could go into the tunnel usually and wipe my finger around the hatch up there and come back with a wet finger.

COLLINS Well, you could see little beads of moisture like on a beer bottle or something like that.

COLLINS There weren't great globs of moisture and, as I say, at 180 hours, it was dry as a bone. When we came to entry, we wiped excessive moisture from the tunnel hatch area. That leads me to believe that it has something to do with the routing of those hoses. If you really cram a set of hoses up in that tunnel as far as it will go and sort of wedge the hoses up around the side of the hatch as far as you can, it might help keep the circulation pattern up. That would keep it fairly dry.

ALDRIN We shot up a batch of film right after TEI. We pitched down and picked up a good attitude to photograph the moon out the hatch window.

COLLINS Yes, we took a whole lot of what I think should be real good pictures.

ARMSTRONG We made a lot of color-comparison checks.

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ALDRIN

Well, we haven't mentioned anything yet about the color as viewed particularly and I guess it is one thing people are going to be listening or looking for before they debrief us. I think that it makes some difference which window you're looking out because the windows do seem to have a little bit of a coating on them. I got the distinct impression that it depended on how you looked out of a particular window, what angle you looked out of it, to tell you just what color you were going to see on the surface. It didn't look the same out of each window. That could answer a lot of questions about the differences that people see and I'm sure that not every spacecraft has the same coatings on the windows. I don't know how significant it is though.

14.6 FUEL CELL PURGING

COLLINS

Fuel cell purging was normal on the way back.

14.7 CONSUMABLES

COLLINS

We finally - we almost caught the RCS budget. Last hack on that, we were 1 percent down and on the hydrogen and on the oxygen we were very close to nominal. Whoever figured those out did a good job.

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14.8 SPS MIDCOURSE CORRECTION

COLLINS None was required on the way back. We did have one midcourse of 4.8 ft/sec which we did with the RCS.

14.9 MIDCOURSE LUNAR LANDMARKS

COLLINS That's not applicable.

14.10 STAR/EARTH HORIZONS

COLLINS That's not applicable.

14.11 ECS REDUNDANCY

COLLINS We did not investigate any of the redundant systems of the ECS.

14.12 DAP LOADS

COLLINS DAP loads were as called out in the flight plan; I don't have any comments on those. We widened up the DAP deadband PTC to 30 degrees, which is really sort of a waste of time in that DAP PTC procedure, because as soon as you widen the deadband, you turn all 12 or 16 of your RCS thrust switches off. It really doesn't matter whether the deadband is wide or narrow, the thing is incapable of firing any thrusters anyhow. The DAP loads as written in the flight plan were satisfactory.

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14.13 IMU REALIGNMENT

COLLINS IMU realign was all right. Throughout the flight, I was able to get satisfactory IMU alignments during the PTC at 0.3 deg/sec. This is a fairly fast rate, and it feels uncomfortable. You have to go to RESOLVE MEDIUM, and you have the feeling that you are lucky to click the stars that pass through the center of the reticle pattern. It's not really possible to track smoothly and hold the star in the center and make a very precise mark. However, the star-angle differences came out usually 00001, so I guess that the accuracy is well within the limits that you would call satisfactory.

14.14 COMMUNICATIONS

COLLINS Again, the ground was changing between OMNI B and D in PTC. When we were stopping PTC, we were getting little snatches of the high gain. Difficulties with that system were traced mostly to ground-switching problems, although you would have to say it is a fairly cumbersome system using the four OMNI's and the high gain. I don't have any suggestions for improving the operating procedures.

ALDRIN It would be nice if the ground had control of that OMNI switch to select any of the four.

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COLLINS Yes, that's true. Right now, the ground can either switch between high gain and D Dog or between D Dog and whatever is selected on the switch to its left, which is normally B Baker.

14.15 BATTERY VENTING

COLLINS Battery venting and waste dumps were all normal, just as they were on the way out.

14.16 POWERING UP AND DOWN OF SPACECRAFT

COLLINS We only powered a few items down each night. We really maintained power for the entire flight, and that was a mode of operation I enjoyed, not having to power down.

14.17 TELEVISION

COLLINS We made a goof on our last television show. We left the circuit breaker out, which allows the monitor to be operable without transmitting. Consequently, we lost a lot of the entry data. It's the one on 225 called S-band, FM transmitter, data stowage equipment flight bus. Of course, the entry checklist didn't mention checking that circuit breaker, because the people who wrote the entry checklist had no idea that it would be out because of a television program hours prior. I guess the TV checklist doesn't mention it either as best I can recall.

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ALDRIN I was sort of disappointed in the ground not catching that. It seemed to me that they might want to make some checkout of the tape because they had control of it before entry, or because we called out to them that the talkback barber-pole didn't go gray.

COLLINS We did lose control of the tape because the circuit breaker was out. I believe that we and the ground both got tricked into thinking it was because we hadn't gone to COMMAND RESET. But didn't you tell them once that you had gone to COMMAND RESET and you still didn't have tape control?

ALDRIN Yes.

COLLINS To make a long story short, we did inadvertently leave that TV circuit breaker out, and therefore, the taped entry data were lost. They'll still have a lot of information through the downlink.

14.18 COAST PARAMETERS - ANOMALIES

COLLINS The machine held together beautifully on the way home. I don't know of any anomalies.

14.19 HIGH GAIN ANTENNA TRACKING

COLLINS High gain antenna tracking was as it always was.

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14.20 S-BAND PERFORMANCE

COLLINS S-band performance was good.

14.21 NECESSITY OF ADDITIONAL IMU REALIGNMENTS

COLLINS The IMU, by this time, had had its compensation terms updated once or twice, and it was in good shape. I don't recall the longest period of time we went without an IMU alignment, but it was on the order of 12 hours. At the end of this period of time, the stars were still well within the sextant field of view.

14.22 MCC UPDATE

COLLINS Midcourse correction update was well handled. We only had an RCS burn.

14.23 W-MATRIX

COLLINS We didn't fool with it; we left it alone.

14.25 PRESLEEP AND POSTSLEEP CHECKLISTS

ALDRIN We talked once about looking into some modifications of the COMM so that you didn't have the two options available, plus referring to another checklist with exceptions. I think there's some way to simplify that.

14.26 PHOTOGRAPHY

COLLINS We took lots of pictures on the way home, using up the remainder of the film. We took photos of the exterior of

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COLLINS the Earth and the Moon at various settings. We'll just
(CONT'D) have to wait and see how they came out.

14.27 PASTIME ACTIVITIES

COLLINS What did we do with our free time? We mostly just waited.

We had plenty of time to eat, had plenty of time to get
rested up. We used simultaneous sleep periods on the way
home. Our inclination during preflight was to use stag-
gered sleep periods on the way home. I'm not sure in
retrospect which is the best way to go.

ALDRIN I didn't see anything wrong with the way we did it.

COLLINS I didn't see anything wrong with what we did, because

nothing broke. Had we had things start breaking, I'm not
sure we wouldn't have been better with the staggered sleep
periods.

14.30 TIMELINES AND FLIGHT PLAN UPDATES

COLLINS There was none that I recall.

14.31 MANEUVERING TO ENTRY ATTITUDE

COLLINS Maneuvering to entry attitude was done easily and early.

14.32 BORESIGHT AND SEXTANT STAR CHECKS

COLLINS We did not have a boresight star, but the sextant star

check passed as it always did.

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14.33 ELS LOGIC AND STAR CHECKS

COLLINS The ELS logic check was done early with the ground looking over our shoulder, and it gave us a GO for PYRO ARM.

14.34 EMS

COLLINS We checked the EMS out insofar as we could the day prior to entry. I think this is a good idea because if there are any funnies in it, then the ground has a good 24 hours or more to have meetings and decide whether or not all or portions of the EMS are GO or NO GO for entry. The DELTA-V counter worked normally in EMS. Accelerometer bias - I don't really recall that we checked that preentry. We just ran through all the self-test patterns, and one of those checks accelerometers when it counts down to zero plus or minus something.

14.35 ENTRY CORRIDOR CHECK

COLLINS The ground kept reporting our gamma, which was indicating a little steep, 65 something. Then we got closer and closer to nominal as we got closer in, and I don't recall what our actual gamma was. I think it was 652.

ARMSTRONG No. 648 was the last we hit.

COLLINS 648 is as close to nominal as you can get.

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14.36 FINAL STOWAGE

COLLINS We had a couple of items, mostly helmets, that did not go according to the entry-stowage plan. The helmets were supposed to go in the foodboxes. Only one helmet fit in the food box and that left us with two helmet bags plus two LEVA bags. These four little packages we bundled up and put inside the right-hand sleep restraint and latched down with tiedown cord. That system worked fine. Our first inclination was to put all those bags inside the hatch bag underneath the left-hand couch. However, the ground objected to that because they thought that the bag wasn't stressed sufficiently for that weight during entry, but I think you could have put 10 helmet bags inside the hatch bag and it would have been perfectly safe. That hatch bag is very strong and it's a very convenient place to stow things even of helmet weight during entry.

ALDRIN We ought to find out what limits North American places on that for entry.

COLLINS You could grab that hatch bag and pull on it with all your might and you weren't about to pull that thing loose.

14.37 SYSTEMS VERIFICATION

COLLINS The systems worked fine.

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14.38 FINAL ENTRY PREPARATIONS

COLLINS Final entry preparations were done early with a good checklist.

14.39 CM RCS PREHEAT

COLLINS CM RCS preheat was not required.

14.40 MANEUVERING TO ENTRY ATTITUDE

COLLINS We used the system of manually tracking the horizon and cross-checking gimbals angles and horizon positions in the window versus time out from 400 000 feet. The ground had given us several check points at EI minus 30 minutes and EI minus 17 minutes. In addition, we had a little graph that showed for any instant in time what the pitch gimbal angle should be to keep the horizon on the 31.7-degree line on the window. All these checks reinforced our belief that we did have a good platform and that we had a good trajectory.

14.42 CM/SM SEPARATION

COLLINS CM/SM SEP went normally. The water boiler was in operation during this period of time, which gave the spacecraft a left yaw. I was in MINIMUM IMPULSE a good percentage of this time, and thus it was quite noticeable. I yawed out 45 degrees left, jettisoned the service module, and yawed back in plane by yawing right. When I got a yaw

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(CONT'D)

rate started, the water boiler would fight me, the rate would reduce to near zero, and I would then have to make another input.

Having gotten back to zero yaw after jettisoning the service module, I noticed there appeared to be something wrong with the yaw-left thruster at this time. It had worked normally for a little while, but after several minutes of operation, it did not. That was command module RCS thruster 16, yaw left. It appeared to be functioning improperly using the automatic coils. When you yawed left, it made some noise, but it did not give the proper response. It would work properly if you'd move the hand controller all the way over to the hard stops and use the direct coil. At this late stage of the game, I didn't want to devote any time to troubleshooting or talking about it. I probably should have brought the number 2 system on the line in that axis, but I didn't; and everything else seemed to be working normally. I'm just flagging that as a possible systems problem; somebody should look at that thruster and its associated wiring after the flight and see if there's anything wrong with it.

FCOD REP

Did you see the service module?

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COLLINS Yes. It flew by us.

ALDRIN It flew by to the right and a little above us, straight ahead. It was spinning up. It was first visible in window number 4, then later in window number 2, really spinning.

14.44 0.05g EMS AND CORRIDOR CHECK

ALDRIN What was the comparison of when the final g light came on?

COLLINS Twenty-eight seconds, I think.

ARMSTRONG When the DSKY indication of the accelerometer acceleration read 5, the 0.05g light came on. At that point, the clock read 28 seconds.

COLLINS The spacecraft was briefly out of the sunlight at 400 K, and all of a sudden the thing lit up and I thought we were starting to get ionization, but it really wasn't that; it was a brief period of sunshine.

ARMSTRONG I wasn't looking out, but there was a weird illumination. I also thought it was just ionization at the time.

COLLINS We got the 0.05g light, and I got the 0.05g switch and the EMS roll switch on. We were cross-checking the clock, and this was 28 seconds after 400 000 feet. I did not

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COLLINS
(CONT'D)

notice the corridor verification light, either the upper one or the lower one. Both of them could have been on. I was busy at this time checking other things, such as were we holding the right bank angles with the lift vector up and did the g on the EMS agree with the g meter. I was also listening to what Neil was saying about the computer. Of course, our intent was to hold the lift vector up unless we had some considerably off-nominal entry with no communications; so we started to do that regardless of what the corridor verification light said.

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15.0 ENTRY

15.1 ENTRY PARAMETERS

COLLINS

Normally we're targeted for 1108 miles from pointer K to the ship. Initially the weather in that area looked good, but as we got in closer, Houston started making grumbling noises about the weather in that recovery area. Finally they said there were thunderstorms there and they were going at 1500 miles. I wasn't very happy with that fact because the great majority of our practice and simulator work and everything else had been done on a 1187 target point. The few times we fooled around with long-range targets, the computer's performance and the ground's parameters seemed to be in disagreement. Specifically, there's an exit velocity and exit-drag-level check that's got to be within certain bounds, and it rarely, if ever, was within those bounds. So, when they said 1500 miles, both Neil and I thought, "Oh God, we're going to end up having a big argument about whether the computer is GO or NO GO for a 1500-mile entry." Plus 1500 miles is not nearly as compatible — it doesn't look quite the same on the EMS trace. If you had to take over, you'd be hard-pressed to come anywhere near the ship.

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COLLINS
(CONT'D)

For these reasons, I wasn't too happy about going 1500 miles, but I cannot quarrel with the decision. The system is built that way and, if the weather is bad in the recovery area, I think it's probably advantageous to go 1500 miles than to come down through a thunderstorm.

15.2 COMMUNICATIONS BLACKOUT

COLLINS

I never paid the slightest bit of attention to that. They read up all the numbers; it's simple that, if you're in a blackout, you can't communicate; if you're either side of the blackout, you can. I guess the ground uses it a little more than that, it can give them more of a hack on where you are relative to the nominal trajectory.

15.3 IONIZATION

COLLINS

Along about .05g, we started to get all these colors past the windows; Buzz took some movies, which we looked at last night. They don't really show what the human eye sees. Around the edge of the plasma sheath, there are all varieties of colors — lavenders, lightish bluish greens, little touches of violet, and great variations mostly of blues and greens. The central core has variations on a orange-yellow theme. It's sort of a combination of all the colors of the rainbow really. The central part looks like you would imagine a burning

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COLLINS
(CONT'D)

material might look. Orangeish, yellowish, whitish, and then completely surrounded by almost a rainbow of colors.

ALDRIN

I thought there was a surprisingly small amount of material coming off.

COLLINS

That's right; there didn't seem to be any chunks as there were on Gemini.

ALDRIN

That's right; there didn't seem to be any droplets or anything coming off. There was a small number of sparks going by; you could definitely see the flow pattern. Looking out the side window, you could get a very good indication of the angle of attack by the direction of motion of the particles. That didn't seem to change too much. When a thruster would fire, you could pick it up immediately, because it deflected the ion stream behind you. I am not sure whether that was because of a roll or whether it was actually changing the direction of the lift vector.

15.4. SOUNDS, SENSATIONS, AND OBSERVATIONS

COLLINS

I didn't hear any unusual sound at all during that time.

ALDRIN

No, it seemed to be rather quiet.

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COLLINS Yes, there wasn't any sizzling, popping, or any noises that you commonly associate with entry heating.

ALDRIN I thought the g constant was quite smooth.

COLLINS I thought it was smooth also.

ALDRIN More rapid from a physical standpoint than I had anticipated.

COLLINS I thought it was slower than the centrifuge. I think it's probably exactly the same time duration.

ALDRIN Well, I didn't have a meter to look at.

COLLINS You're more keyed up and time seems to go more slowly. Anytime that I go from zero g to positive g, I get a feeling of transverse acceleration instead of feeling like that of what it truly is. The first few seconds I get the sensation of body rotation, mostly in pitch. Usually I think we're pitching up.

ARMSTRONG Yes, I would agree that I felt a little bit of a rotational sensation during the initial g pulse, but it's not disorienting.

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15.6 CONTROL MODE

COLLINS

We gave Spacecraft control over to the computer after we passed all our pitch attitude cross-checks. We gave it to the computer shortly before 400 000 feet. I don't recall exactly when, but a matter of seconds before 400 000 feet. We stayed in CMC, AUTO for the rest of the entry. The computer did its usual brilliant job at steering. We just sort of peered over its shoulder and made sure that the spacecraft was responding to the bank angles that the computer commanded, and that those bank angles made sense in light of what we saw on the EMS and through other bits and pieces of information. The computer did not fly the EMS the same way I would have flown the EMS. As soon as it got subcircular, it seemed to store up a lot more excess energy than I thought was reasonable. It was holding on to an approximate 250 miles downrange error. When the downrange distance to go was, say, 500 miles, it would have about 750 miles available at that particular g level we were seeing at the time. I thought this was probably a little excessive, but it hung on until very, very late in the game and then it decided all of a sudden to dump it. It sort of rolled over on its back and gave us a second peak pulse of 6g's

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COLLINS
(CONT'D)

getting rid of that excess energy. After that, everything was all cross-ranges and downranges, and everything made sense. It was essentially on zero error for the remainder of the run. Our first peak pulse was 6.5 as nearly as you can read that thing, and the second one was 6.0.

The EMS trace looked more like a roller coaster than a horizontal line. It really climbed for altitude after the initial pulse and hung way up there high. All of a sudden, it decided to dump it, and rolled over on its back and we came screaming back in. That is really a pretty gross exaggeration, but that was the trend.

15.8 DROGUE CHUTE DEPLOYMENT

ALDRIN

I could see the ring departing just a fraction of a second before I felt a small pulse. There wasn't much of a rotation as the drogue chutes deployed. They seemed to oscillate around a good bit, but did not transmit much of this oscillation to the spacecraft. The spacecraft seemed to stay on a pretty steady course.

15.9 MAIN CHUTE DEPLOYMENT

ALDRIN

The main chute deployment again gave us a small jolt, but not one that would move you around in the seat appreciably or cause any concern. I can't say that I

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ALDRIN
(CONT'D)

noticed the difference between first deployment and dereefing. It seemed to be one continuous operation.

COLLINS

It seemed to me there was quite a bit of delay before they dereefed. All three chutes were stable and all dereefed and they kept staying that way until I was just about the point where I was getting worried about whether they were ever going to dereef; then they did.

15.10 COMMUNICATIONS

COLLINS

As soon as we got out of blackout, we heard Recovery 1 and Hawaii Rescue 1. Houston, as per agreement, stayed off the air and we pretty much stayed off the air except to speak when spoken to and to let the recovery people know that we were in good shape and that there was no hurry about their recovery operations.

15.11 ECS

COLLINS

We did not have suits on. We brought the primary water boiler on the line as per the checklist; the same for the secondary. They were brought on roughly 45 minutes and 15 minutes, respectively, before separation, something like that. I don't think the secondary boiler really had a chance to do any boiling; however, I believe the primary did.

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ALDRIN

At any rate, it started perking away. You can't tell how effective it is by looking at the gages.

COLLINS

The cooling was very good. Even during the entry itself, we were perfectly comfortable. We didn't have to freeze ourselves out by cold-soaking prior to entry. We didn't go through any cold-soak procedure. It was pleasantly cool throughout the entry, and it was quite comfortable on the water, as opposed to our Gulf-egress training. I think you'd get an entirely different viewpoint of that recovery operation with the BIG's, if you started out hot with stored body heat.

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16.0 LANDING AND RECOVERY

16.1 TOUCHDOWN - IMPACT

COLLINS I felt a solid jolt. It was a lot harder than I expected.

ALDRIN It pitched me forward with a little bit of sideways rotation. I was standing by with my fingers quite close to the circuit breaker. The checklist fell, and the pen or pencil, whatever I had, dropped. It didn't seem as though there was any way of keeping your fingers on the circuit breakers.

ARMSTRONG When you are 18 knots away, it looks pretty promising.

COLLINS I think those procedures for the main chute are well worked out. I think it is 50/50 whether or not you are going to Stable II.

16.3 POSTLANDING CHECKLIST

COLLINS The postlanding checklist worked well. The big item for us was that we not contaminate the world by leaving the postlanding vent open. We had that underlined and circled in our procedures to close that vent valve prior to popping the circuit breakers on panel 250. I'd like to say for the following crews that they pay attention to that in their training. If you cut the power on panel 250 before

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(CONT'D)

you get the vent valve closed, in theory, the whole world gets contaminated, and everybody is mad at you.

ALDRIN

I have a couple of things noted in the checklist. I don't think any of the flights have ever used the CM RCS preheat. If you miss a circuit breaker, it is not real obvious that you are going to come back and see that circuit breaker later. You do, but it is tucked away. For example, when you get ready to preheat, you push some circuit breakers in and turn the heaters on. You wait awhile then pull some circuit breakers out again. The way the checklist is written, some of those circuit breakers stay in and you wonder whether you ought to go through the mechanics of checking all those things off. The other one is the CM RCS activation. When we got to the point of bringing the various logic switches on, the sequence arm circuit breakers were out. Mike called it to my attention that unless we pushed those in, we weren't going to get any RCS pressurization. We didn't go back and research this at that particular time. I believe that if the checklist people check, they will find that those circuit breakers should be called out to be pushed in at that point.

During the CM RCS check, it says to go to spacecraft control SCS, but it doesn't tell you what mode to be in for

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ALDRIN
(CONT'D)

the check. I think you want a minimum impulse. I think that it is logical that it be called out in the checklist.

16.4 TEMPERATURE AND HUMIDITY

COLLINS

It was definitely humid inside. We got about a quart of water in through the snorkle valve. It was definitely humid, but it was comfortable.

16.5 COMMUNICATIONS

COLLINS

Communications were good after we became stable I. Of course, we could not hear anybody in Stable II, because the antennas were in the water.

16.7 BATTERY POWER

COLLINS

Battery power was more than adequate for the brief duration we were in the spacecraft. I don't recall the voltage, or you mentioning it.

ALDRIN

On the main chutes after we dumped propellant during the purge cycle, you could see flame coming out of the thrusters and going by the side windows. When we opened up the valves, there was a fairly strong odor of propellants. It didn't last particularly long. It seemed to me we had plenty of time, and it might be advisable to delay that a little bit longer.

CONFIDENTIALALDRIN
(CONT'D)

The visibility out the side window coming down was quite good and I felt that you could look out and almost see impact by looking out to the side. This would involve some risk to your neck at the time. I think you could determine levels of 50 feet or less and then put your head back on the couch. I didn't see any need to do that, but the capability does exist.

This business about hitting the water without putting the chutes out because of altimeter failure is kind of a "Mickey Mouse" simulator pad.

COLLINS

I think it is a good thing though. I think the more answers you can mess up inside the simulator, the better it is. They ought to trick you into coming in with your PYRO circuit breakers out, with your ELS circuit breakers out, with your PYRO's not armed, with your ELS logic off, or with your ELS AUTO switch in MANUAL. Any one of those things can really foul you up. To get a successful entry, you have to have the ELS circuit breakers in, the PYRO's armed, ELS AUTO on, and the ELS LOGIC on. Those are important things in the 101 checklist items. Most of them are really not critical, but those few items are. I managed to foul each one of them up at least once during the various simulations. I was glad that I had because I was darn sure

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16-5

COLLINS
(CONT'D)

going to make positive that each of those switches were in the proper position.

ARMSTRONG

I agree with that. What Buzz is saying is that this lack of information about how high you are is not real. If you are in a lighted condition, and we were in a relatively well-lighted condition during chute deployment, this information is a lot more readily available in flight than it is in simulator. You can see the clouds coming up, and you are watching yourself go through cloud layers, and then you can see the water down below you. You have a lot of cues as to how high you are which aren't available in the simulator.

ALDRIN

That's true.

16.10 SEASICKNESS

COLLINS

Nobody got sick. We each took a pill prior to entry and a second pill on the water. Those pills are called Hyacynth and Dexedrine, and they seem to work fine.

ALDRIN

No side effects at all.

16.11 INTERNAL TEMPERATURE CHANGES

COLLINS

There didn't appear to be any. We were comfortable on the water, and I guess at the time it probably warmed up a

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~~CONFIDENTIAL~~COLLINS
(CONT'D)

little. We weren't in it long enough to really feel any sudden changes. There weren't any.

16.12 STABLE I OR STABLE II - UPRIGHTING PROCEDURES

COLLINS

We were in Stable II. The float bags worked fine. We were in Stable II 4 or 5 minutes.

ALDRIN

It didn't seem like it was anywhere near as long as it was during the tank or Gulf training exercises.

COLLINS

I am sure the reason was that we were bobbing around fairly well.

ALDRIN

As soon as they became almost full, the wave action tipped it back over.

COLLINS

That's right.

16.14 INITIAL SITTING OR STANDING

COLLINS

I don't think any of the three of us had any of those symptoms.

16.15 INTERNAL PRESSURE

COLLINS

Internal pressure was fine. We used the dump valve as per the checklist, and it worked out well.

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16.16 RECOVERY OPERATIONS

COLLINS Recovery Operations went very smoothly. The swimmer threw the BIG's into us. We put the BIG's on inside the spacecraft. We put them on in the lower equipment bay. Neil did first, then I did after him. Buzz put his on in the right-hand seat. We went out; Neil first, then me, and then Buzz. It's necessary, at least the way we had practiced it, for us to help one another in sealing the BIG's around the head to make sure the zipper was fully closed.

16.19 EGRESS

COLLINS As we crossed the threshold of the hatch, we inflated our water wings and jumped into the raft. The BIG's swimmer had trouble getting the hatch closed. I don't know why. Neil went back to help him, and he still had trouble. I went back to help, and when I got there the hatch gear box was on neutral and the hatch handle was on neutral. He should have been able to close it. The hatch handle, instead of being up at its detent, was flopping free. All I did was take it and cram it up into the detent. Then he was able to close the hatch. He was really cranking on it. With neutral on those two pawl settings, there should be no impediment to closing the hatch. Even if the hatch handle is flopping loose, there isn't anything inside

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~~CONFIDENTIAL~~COLLINS
(CONT'D)

which mechanically would interfere with it. We finally helped him get the hatch closed.

We sprayed one another down inside the raft. There was some confusion on the chemical agents. There were two bottles of chemical agents. One of them was Betadyne, which is a soap-sudsy iodine solution, and the other one was Sodium Hypochlorite, a clear chemical spray. During our simulations, we used Betadyne in both bottles. They found that the Betadyne broke down the waterproofing in the suit. They made a last-minute change and used Betadyne for scrubbing down the spacecraft, but they used Sodium Hypochlorite for scrubbing us down. I had read about this and knew that there was a change. While the swimmer was scrubbing the spacecraft, I grabbed the other bottle and started scrubbing Neil down. The swimmer got excited and didn't want me to do that. I found out later it was because if you inhale enough of this Sodium Hypochlorite through your intake valve you can cause problems inside the BIG. I'm not sure whether you get nauseated, you can't see or your eyes water.

You have to be careful and not spray too vigorously around the intake valve. You have to spray your glove and wipe it on rather than spray it directly on. I am sure future

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COLLINS
(CONT'D)

recoveries will have this worked out during their Gulf egress training. < This is just another example where changes made between the training and the real thing have the potential of biting us. >

ALDRIN

I thought the BIG was a well-designed garment. I was rather disappointed in the visibility. When we had our training exercise in the Gulf, I didn't notice as much fogging over on the inside of the visors as I did on the actual recovery. I thought for a while it was on the outside. I dipped down in the water, but couldn't seem to clear it at all. I don't know where it came from. It didn't seem to me that I was perspiring that much on the inside.

ARMSTRONG

I was just about to comment on the same thing. If there were any disadvantages to the BIG, as they were used in this operation, it was the lack of visibility due to condensation on the inside of the visor. It was so bad as to be nearly opaque.

COLLINS

I didn't notice that it was any worse than the Gulf. I could see the helicopters clearly, the sling being lowered, and the swimmers. I could make out enough detail, for example, to read the face of a wrist watch. I could see fairly well.

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ALDRIN You could, but you would have to move it around to a clear spot.

COLLINS Maybe that's true.

ARMSTRONG It may have had something to do with the seal between the face and the mask.

ALDRIN Yes.

ARMSTRONG How tight that seal was determined whether or not that condensation was excessive or not. Perhaps you had a tighter seal. I think that my seal was fairly loose.

COLLINS So was mine. You remember, you wanted to tighten my mask.

ALDRIN I tightened mine down. Mine was pretty tight so that I wasn't breathing in and out of the suit. Maybe that fact contributed to mine fogging up.

COLLINS Could be. I don't know

ARMSTRONG I had a loose fitting mask, too. I had the same problem.

16.21 CREW PICKUP

COLLINS We got into the raft, did our decontamination bit, and they picked us up. The helicopter pilot was real good. You put

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16-11

COLLINS
(CONT'D)

one hand or foot anywhere near that basket, though, and they start pulling. They don't wait for you to get in and get all comfortable before they retract. Just like a fisherman, they felt a nibble on the end of that line, and he started cranking. Aboard the helicopter, we started storing heat. For the first time I became uncomfortably warm during the helicopter ride. That helicopter ride was as short as we are going to have them during this kind of operation. We debriefed the recovery people out on the ship and told them the same thing. When you get the crew on the helicopter, everybody shouldn't sit back and breathe a sigh of relief and think that the operation is all over; they should keep right on moving. This is the time when the crew is really starting to get uncomfortable. If the crew has to stay in that helicopter 15 or 20 minutes longer than we did, I guess the hood on the BIG would come off. That's a pretty wild guess.

ARMSTRONG I agree.

ALDRIN I agree.

ARMSTRONG I think we were approaching the limit of how long you could expect people to stay in that garment.

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*the Biological
Isolation
garment*

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COLLINS It was all right in the raft.

ALDRIN The roughness of the water didn't bother me too much. The fact that we were getting just a few waves every now and then cooled you off. There was no way of measuring what the inside temperature of the chopper was except that we just started accumulating heat inside the suit.

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17.0 GEOLOGY AND EXPERIMENTS

COLLINS I thought that the maps were more than adequate — those that were carried onboard the command module. The grid system could be improved on. I think the ground sort of, in real time, came to the same conclusion we had — to call each grid the letter defining its lower boundary and the number defining its left-hand boundary and using sort of a Vernier scale across the grid square. In other words, if you want to define a spot in grid square E9, you consider E9 the one whose lower left-hand corner is the intersection of E and 9. If you want to get specific, you say E.9 and 9.13 or something like that; and that defines within that square more specific coordinates.

ALDRIN The numbers, if yours were the same as ours, had some pattern to them; but they didn't have as much pattern as I think could have been employed. In other words, they could have just gone straight across left to right in each row.

COLLINS Here's mine. I'm talking about the LAM-2 map, and it was okay. It's no jewel of a map, but it was certainly adequate.

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ARMSTRONG This section is going to be difficult to do without the pictures to describe. We're going to take an hour to talk about some of these things that you could talk about in 30 seconds with the picture.

[EDITOR'S NOTE]

The remainder of the items listed in Section 17 were covered in considerable detail in the air-to-ground transcription and/or Section 10 (Lunar Surface) of this document.

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18.0 COMMAND MODULE SYSTEMS OPERATION

18.1 GUIDANCE AND NAVIGATION

COLLINS I have no comment about the ISS. Optical subsystem B2, light transmittance telescope and sextant - as we said previously, the sextant was a very useful instrument as long as the platform was kept in alignment within plus or minus 0.9 degree. Then stars would be visible in the sextant and it was very useful. The telescope, on the other hand, was a very poor instrument because of the light loss through it, not being able to detect star patterns without a considerable period of dark adaptation. That's all I got on that.

18.1.3 Computer Subsystem

COLLINS We raised the possibility of making a PTC program. The computer probably has enough memory to do that if you start deleting things like stable orbit rendezvous, stable orbit midcourse P30, a P39 perhaps. We had no restarts or any funnies in the computer.

18.1.4 G&N Controls and Displays

COLLINS G&N controls and displays were all without surprises. No comments.

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ARMSTRONG I have one comment on the EMS. I think a review of the residuals from each burn that was made would indicate that there is something we don't understand about properly computing ΔV_C , because there seems to be a definite similarity between the residuals. It does not seem to be proportional to the burn size or burn time or any of those things. I always end up with 4 or 5 ft/sec of ΔV_C .

COLLINS The other peculiarity of the EMS was during transposition and docking. The EMS functioned normally during the separation from the S-IVB and the subsequent acceleration, but after the turn around, after the 180 degree pitch and the 60 degree yaw, the numbers in the EMS did not make sense. Instead of being around 101 or 100.6 to 101, they were down below 100. Then, in fact, I docked with the EMS reading 99.1, which is completely nonsensible. I don't understand how or why the EMS got jolted off its correct values during that turn around.

18.4.1 SM RCS

COLLINS On the SM RCS system, we had one quad that was considerably noisier than the others and I don't understand exactly why that was. I don't even remember which one it was. I think it was quad A.

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18.4.2 CM RCS

COLLINS I think there is something wrong with the AUTO coil functioning on thruster 16.

18.5 ELECTRICAL POWER SYSTEM

ARMSTRONG Any comments?

ALDRIN Worked like a dream. The initial battery charging was a little surprising in that the voltage was quite high when the battery charger was first turned on. It was up around 39.2 or 39.3. It later went back on down and the amps went up. I don't really understand what the cause of that was. I called it to the attention of the ground and they seem to think it was normal, but I don't understand it. I got in the habit of using the battery bus indicator whenever I turned the main bus ties on and off, just as a confirmation of doing that. I just mention that for any use of follow-on crews.

18.6 ENVIRONMENTAL CONTROL SYSTEM

COLLINS There was one funny in the ECS, and that had to do with the primary glycol evaporator outlet temperature getting lower than normal one time during lunar orbit when I was in the command module by myself. It seemed to be a transient condition. The system recovered and began

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COLLINS
(CONT'D)

functioning normally. It gave the appearance of the bypass valve having malfunctioned and putting fluid that should have been bypassed around the radiators and through the radiators, resulting in a RAD OUT temp that was too low and a glycol EVAP temp that was too low. And after just sitting there for a while watching it, the system slowly recovered and for the remainder of the flight, the primary glycol loop worked perfectly normally. So there was apparently some transient there which I am unable to explain.

ALDRIN

On the ECS, it seems to me in that rapid REPRESS package we would have a better gage than that one that goes up to 1200 but has marks every 300 psi. That's not a big thing. You don't refer to it very often, but it's just not a very easy one to read, and it's not very sophisticated.

ARMSTRONG

You might mention this inadvertent operation of the press-to-test valve a couple times.

COLLINS

On the oxygen panel, the emergency cabin pressure regulator push-to-test button - we hit it with our toes several times, and it made the ground nervous to see a sudden inflow of oxygen to the cabin on the TM. I don't

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18-5

COLLINS
(CONT'D)

know where they pick off their TM. We heard a little hissing noise that didn't pass more than a second or two. For some reason, our feet banged into that area during the first day or two. A couple or three times we did push-to-test that little button.

ARMSTRONG

Any trouble with CO₂?

COLLINS

No, I had no trouble. They wanted a time in and a time out recorded on the CO₂ canisters. I did write the times on the side of the canister, both in felt-tip pen and with a regular mechanical pencil. It would be easy to put some kind of sticker or to provide some place on the side of the canisters to write on. They are very dark metal, and they are very slippery. It's very difficult to write on, even with the felt-tip or pencil so that they will be legible. I recorded in and out times on each of the canisters, but I'm not at all sure they will be able to read that information.

ALDRIN

It's kind of silly to record those in and out times on the ones that you jettison with the LM.

ARMSTRONG

On the other hand, it's not much trouble to write the times down when you're making the change.

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COLLINS Yes, if we never got into the LM for some reason, I suppose they would want all that information.

18.6.2 Cabin Atmosphere

ALDRIN I noticed occasionally when my eyes would water, there would be a certain noticeable burning. This occurred when water would drip around, and part of that I guess is due to zero g. It's primarily when you wake up in the morning. My eyes would just start to water, and I would notice the burning.

COLLINS Well, something else I noticed in the way of eye irritation was that the male Velcro that's mounted on the spacecraft would come apart in little tiny bits and pieces. That material would get on your skin. A couple of times I noticed eye irritation in the inner part of my eye, and I'd get my finger and peel off a little segment of that Velcro. That happened more than once. That stuff floats around the cabin and can get into your eyes.

18.6.3 Water Supply System

COLLINS The chlorine injection port became more and more difficult to use. The chlorine seemed to corrode the metal, and the chlorine injector assembly became covered with sort of a black slushy-looking deposit. I think it was a chemical

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COLLINS
(CONT'D)

interaction between the chlorine and/or the buffer and the metal. The friction in the system got higher and higher, and toward the end of the 8 days, it was very difficult to screw the ampule assembly into the injector.

COLLINS

The filters I think are a good idea, but they need some more engineering done on them. The basic problem is the back-pressure characteristic or the range of back pressures which will result in satisfactory filter operations. The back pressures should be held to a minimum, and, of course, as long as you are just squirting water through the gun into your mouth, for example, the filter seemed to work pretty well. It still allowed some gas to get through. I think under all circumstances some gas got through. I couldn't really measure that, because you can't see the water in your mouth. However, I just had the feeling when squirting the water gun in my mouth through the filter that the water still had some gas in it. But it was a lot better than it would have been without the filter. Hooking a food bag up to the filter or a drink bag changed this situation. It depended upon the individual characteristics of each bag just how much the operation was degraded. Some bags had very nice, smooth openings in them, and some were crinkled and wrinkled.

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CONFIDENTIALCOLLINS
(CONT'D)

You really couldn't open up a sufficient orifice behind the valve so that the water gun would be pumping against the back pressure. This, I think, degraded its efficiency. The dispenser in the LEB is a 1-ounce dispenser and without the filter attached, every time you depress the plunger you get a very forceful ejection of 1 ounce of water with a very definite beginning and end to it. With the filter attached, you depress the plunger and you get about a half ounce of water rapidly ejected, followed by a very slow oozing out of another half ounce. In other words, the filter acts as sort of an accumulator for the system. Since that second ounce appears very slowly over a long period of time and hangs there as a globule on the end of the filter, it sort of makes for a leakage problem. Whenever you try to fill a water bag or food bag with either hot or cold water from that spigot down there, you have to wait an awfully long time after the last squirt to let the water come through the filter. Even so, you are going to get a lot of leakage after you disconnect the water bag, because at the instant you disconnect the bag, the back-pressure characteristics are changed and the oozing increases. So, in general, it was just sort of a sloppy operation trying to use the filter with a lot

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COLLINS
(CONT'D)

of spillage. You had to really get down there with the towel every time you wanted to fill up the water bag. On a couple of occasions, we really put the back pressure to it. I remember one time, the entry port to one food bag was totally blocked and we were trying to squirt water into a deadheaded system. Under these circumstances, my preflight briefing indicated that relatively irreversible damage would be done to the filter, and we would have to take it up out of the line and go through a drying procedure of several hours' duration. We found this was really not the case. We could see the membrane deteriorate, and then little beads would appear on it. Yet if we just let the filter alone for several hours, it appeared to us that the efficiency was restored.

ALDRIN

It seemed to be a mechanical problem, also, of attaching the bags. Without the filter, the nozzle of the gun would stick inside the bag valve, opening with enough friction and with the O-ring fitting tight enough so that you didn't have to push with any appreciable force to retain the bag on the end of the gun. You could confidently squeeze the trigger and squirt the water into the bag without fear of squirting the bag off the end of the gun. But that wasn't true with the filter on there.

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ALDRIN
(CONT'D)

First, the filter didn't have a good locking device to keep it on the gun. When I put the end of the filter into the bag, I found that I had to continually push the bag to retain it on the gun.

COLLINS

That O-ring is just insufficient.

ALDRIN

The opening on the end of the filter isn't quite long enough, either. And I found that to work it better I'd have to cut a good bit closer to the nozzle end than the line would indicate. This would let you get the end of the filter farther into the bag without the bag interfering with where the nozzle of the filter wasn't long enough.

COLLINS

We can get together with Al Tucker and show him exactly.

ARMSTRONG

The filter took some gas out, but not all. Of course, efficiency of the filter varied widely depending on what the back pressure situation was.

ALDRIN

The problem with the gas in the bag is one of difficulty in mixing the water and whatever is in there. There is some discomfort when you swallow a fair amount of gas, but the biggest thing, I guess, is the fact that you just pass more gas. Of course, that's a big odor problem in the spacecraft.

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COLLINS I beg your pardon.

ALDRIN I beg yours.

18.6.4 Water Glycol System

ARMSTRONG Let's go on to water glycol system.

COLLINS Water glycol; no comments. There was the one funny on glycol evaporator outlet temperature in lunar orbit being too low. The secondary glycol loop check when we got a small decrease in the accumulator quantity is something that perhaps should be explained a little better preflight so that it came as no surprise.

18.6.5 Suit Circuit

COLLINS Nothing.

ARMSTRONG Just the O₂ flow sensor in the suit circuit.

COLLINS Well, that's not really a circuit. That's on the 100 psi line, but I think that's well documented. All we can say is the transducer was sick, or somehow the O₂ flow sensor onboard reading was out of calibration. It read lower than the flow rates we were actually getting, and its degree of accuracy seemed to change with time.

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18.6.6 Gaging System

COLLINS The flow rate again; that's the only thing.

18.6.7 Waste Management System

ALDRIN Yes, I think there is some question as to the capacity of that waste management container and the ability to fully utilize it. I wasn't convinced that we didn't have a good bit more room than we thought we did, but there wasn't any real way of knowing how much additional volume you had available. And I wasn't too successful in being able to put my arm in there and push things down.

COLLINS I had a smaller arm. I could get my arm down not quite around the corner. I could get it far enough down to sort of try to keep things moving to the bottom of the barrel. Again, I guess I didn't have a precise handle on how much that would hold. I knew that it was just a fairly large compartment. I think we could have stuffed more things in there than we did. On the other hand, we did have a priority system of what we thought should go in there. The smellier it was, the more desirable it was to have it inside that compartment. I thought it worked out fairly well.

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ALDRIN

Yes, but I think it's worthy to note here that we did use one of the temporary stowage bags as a trash container before we got into lunar orbit, and then dumped that stuff in the LM. On the way back, we had two other trash containers. I think most of this was because of our lack of confidence in how much we could put in the waste stowage container.

COLLINS

I think there's got to be a better way of fecal containment or disposal. I'd like to talk to the experts on that some time later, apart from this debriefing.

18.7 TELECOMMUNICATIONS

COLLINS

I thought communications in general worked very well. I think the problems that we had were ground switching problems. We did have extended periods of time without communications with the ground when we were in line of sight with the ground. I don't quite understand all the reasons for that. I'm sure somebody else is worrying with the problem more than we are. The VERB 64, I thought, worked well. The only trouble with 64 is that it is a continuous computation. It ties up the computer to the extent that they've designed it where you have to be in POO to read VERB 64. I'm not sure that if you had to do it

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(CONT'D)

over again that would be the best way to design it. I don't know why you couldn't have VERB 64 available in P20, for example. But, in general, all that worked well. Again, we should note that we left the circuit breaker out for the television on panel 225, and that made the onboard tape not available during entry.

18.8 MECHANICAL

COLLINS

Tunnel, probe, drogue, lighting, all worked beautifully. We inadvertently activated the lower left-hand strut softener prior to launch. It was done when hand-controller number 2 was moved and pulled the fabric line that attaches to the strut. We recommend that the backup CMP, or whoever is in there, understand how to reset those strut softeners.

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19.0 LUNAR MODULE SYSTEMS OPERATIONS

19.1 GUIDANCE AND NAVIGATION

ALDRIN

The dimmer control was adequate. You could tell, as was commented on previous flights, that in the dim range, there isn't a wide range of control. I felt that (for the service alignments anyway) what was available was adequate. I was a little disappointed in the ability to focus the reticle into a sharp image. I thought we'd be able to get that a little sharper. It didn't seem to be quite as pressed a reticle as I was able to get in the simulator. I can't explain why that was.

The rendezvous radar worked as expected, or better.

I thought the signal strength of Borman's on the side lobes was just what we expected, very close to what the simulator depicts, in rise and drop-off.

ARMSTRONG

We've commented already on the inaccuracy of the simulator line-of-sight needles. That should be changed.

I only have one discrepancy on the landing radar — that of the alarm on landing radar position — that we couldn't explain.

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ALDRIN That's probably a computer problem more than a radar problem.

ARMSTRONG Yes.

ALDRIN I think the zero Doppler effects down around a 100 feet when the noise came on and then went back off again should be fairly well documented. It was a rather brief period, on the order of maybe 5, 6 seconds, that both altitude-velocity lights came on. Then they went back out again.

ARMSTRONG In fact, I think the zero Doppler drop-outs were less than we expected.

Concerning the computer, anything on this 56 or 57 here?

ALDRIN The overloading of the computer is pretty well understood. It's unfortunate that, because of that, you are not able to take advantage of the use of the radar to designate during ascent.

The DSKY, the keyboard that is, we managed to wear out in the simulator. Quite frequently, it would require depressing the keys several times before the entry would be accepted. But the flight keyboard worked very well. I didn't notice that it required any unusual amount of

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ALDRIN
(CONT'D)

force to get any of the key strokes to take.

AGS seemed to work extremely well. The one lighting failure that we previously mentioned in the middle character; the upper left-hand vertical stroke was not lit. This was noticed on initial checkout when a 3 or 9 would come up. Because this particular one was blank, it wouldn't look like any particular number. By filling in one or the other, you could make it either a 3 or a 9. Anyway, there was some possibility for confusion. However, it didn't appear critical.

19.2 PROPULSION SYSTEM

ALDRIN

It seems to me that, in monitoring the gyro calibrations addresses, I did notice that one of them increased to a larger number during the calibration than it finally settled out at. I'll just ask that question of the Systems people when they get there.

ARMSTRONG

We had no abnormalities with the descent engine or ascent engine. We've commented already on the ascent source pressure; that is, confusion with respect to whether or not both tanks had pressurized.

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19.3 REACTION CONTROL SYSTEM

ARMSTRONG No problems.

19.4 ELECTRICAL POWER SYSTEM

ALDRIN Everything worked just as expected. The monitoring, the displays were quite close to what we've seen in the simulator. One small point — in checking the ED batteries in the simulator, when you'd push the spring-loaded switch, there is some delay before the meter gives you the battery reading. In the spacecraft, this is not the case. It's almost instantaneous. When the switch is placed in either A or B position, the reading comes up immediately.

ARMSTRONG And there were no difficulties with the ED systems. All worked well, within our ability to monitor its operation.

ALDRIN In the explosive system, we could hear most of the explosive devices when they were actually fired. I can't recall any that were used that were not audible in the cockpit.

19.5 ENVIRONMENTAL CONTROL SYSTEM

ARMSTRONG We've discussed the CO₂ sensor abnormality and we've discussed the water in the left-hand suit.

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ALDRIN

We also mentioned the slight delay we had in getting the replacement primary canister in. It was a question of not being able to rotate it properly. Then the cap would not go on and completely lock until I was able to just jiggle the canister and get it to insert and rotate properly. It was typical of the sort of difficulties that many people have been having with the cartridge replacement in both primary and secondary. We talked about the temperature levels in the suit on the surface. We explained that rather thoroughly. The temperature got cold before we realized it and, by the time we did, there wasn't much we could do about it to warm it back up in the cabin.

ARMSTRONG

Water supply problems. Concerning the suit circuit, we've talked about the water problem. I believe, in retrospect, probably the secondary water separator did, in fact, successfully keep the water out of the left-hand suit after about 15 minutes of operation.

19.6 TELECOMMUNICATIONS

ALDRIN

No comment other than its being a little unwieldy in switching from HIGH GAIN to OMNI just before LOS and then picking up communications again coming on the other

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side. It seemed to work quite well, with the exception of the attitude we were in approaching powered descent. This produced many drop-outs and required the use of manual reacquisition. Actually, the AUTO would not stay on for a good bit of the face-down portion of the powered descent. I had to make adjustments manually in both pitch and yaw to keep the signals turned on. On the recorder, I think that the previous flights did not spend enough time in the LM to be concerned about the capacity of the recorder, whereas we were going to be in the LM for approaching 30 hours; this being three times the capacity of the recorder. So we did have to attempt to devise some system of turning it on and off depending on our needs. It seems to me that what is really needed is a separate recording system in the LM (and, for that matter, in the command module) that is voice-operated, that turns itself on upon receiving the first signal and turns itself back off again. There's no need for any crew activity to turn switches on or off. It doesn't depend on the operation of the individual audio centers.

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20.0 MISCELLANEOUS SYSTEMS, FLIGHT EQUIPMENT, AND GFE

20.2 CLOCKS

ARMSTRONG Want to comment on the LEB mission timer first?

COLLINS In the command module, the LEB mission timer ran slow.
The first time we checked it after lift-off, it was 10 seconds slow. We reset it to the NOUN 65 value, and the next day it was 3 or 4 seconds slow.

ALDRIN I think it slipped a digit. This was probably the cause for its being off.

COLLINS No, I think it just ran slow. The digit that slipped was in the tens of hours digit. For example, when it was supposed to be 134 hours, it was reading 144 hours. That happened, though, after you guys left the lunar surface; and I'm sure it is as a result of my having manually set it to LM nominal lift-off time.

ARMSTRONG I don't know how that thing runs slow.

COLLINS It did indicate that - -

ARMSTRONG It never agreed with the other time; it was always off by a varied amount, on one digit or another.

COLLINS In addition, there was a small crack in the glass.

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ARMSTRONG Of course, the LM mission timer failure on touchdown was documented during flight. The next day, we were able to reset the time with it; a 30-second reset.

ALDRIN I think it's worth noting that I feel that it's extremely unfortunate that we don't have clocks that count down to zero and then reverse and count back up again. It's forced on the crew anyway. I think other crews are doing the same thing; setting clocks to count up to a burn and then reach 59 and 60 at ignition, just so that you will have a clock that's counting up during a burn and postignition time. I don't expect this to be done immediately. I'd sure like to have it recorded for posterity that clocks would operate much better if they counted down to zero and then back up again without requiring the throwing of a switch at a critical ignition time to get the clock to do that.

20.6 CLOTHING

COLLINS The constant-wear garment looks to me like something that has more work put into it than it really deserves. The results are less satisfactory than they'd be if we just went flying in our regular old summer flying suit. Summer flying suits have more pockets in them and more places to stow things. They are garments in which we feel completely

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COLLINS
(CONT'D)

at home and they are more comfortable than the two-piece CWG. If the CWG has to be made out of a fireproof material, then regular old summer flying suits can also be made out of that same material. It would save considerable money just to delete the custom-tailored CWG and let us pack summer flying suits made of the appropriate material.

ARMSTRONG

I think we've discussed the BIG in some detail during recovery.

ALDRIN

Under coveralls, I think both you and I noticed a slight itching in the forearm. It was probably just a question of wearing through the Teflon liner.

COLLINS

I'd like to go back just a second here and interrupt. I wasn't talking about the constant-wear garment. I was talking about, I guess, the flight coveralls. I can't even keep the names of them straight. The two-piece white jobber that you wear. The underwear I was not criticizing.

ARMSTRONG

I agree with Buzz. There was, near the end of the flight particularly, some irritation of the forearms and elbows, which I think is reaction to the Fiberglas. We noted this before in altitude-chamber runs and so on; and concerning the Teflon-coated garments, I think that it was just a

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ARMSTRONG
(CONT'D) breakdown through continued wear that exposed the Fiberglas through the Teflon and caused a typical reaction.

20.7 BIOMED HARNESS

ARMSTRONG Now in the BIOMED harness area, we had a few discrepancies.

ALDRIN Yes, I had two that I'd like to note. Both of them have been documented. The center chest lead dried out, and I was requested to make a change in that, which I did. The right lead on the right side of my rib cage evidently rubbed against the suit and caused a minor laceration on the aft part of my side. I don't know if there is any way around that other than just not wearing those things.

ARMSTRONG With respect to sensors and harnesses causing discomfort, from about the middle of the flight on, the sensors were essentially itching. I had a tremendous desire to scratch them off.

COLLINS That's right.

ARMSTRONG I scratched all around every sensor about a thousand times. That's just an inconvenience and a distraction.

COLLINS I think part of it has to do with shaving your chest and then the hair starts growing back underneath the plastered-down sensor. That was the impression that I had of it.

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COLLINS
(CONT'D)

The ones that itched the most were the ones with the most hair around them. They left little marks that went away in a day or two.

ALDRIN

Let's digress to the lightweight headsets. I've found it preferable to use the lightweight headsets instead of the COMM carrier. It still didn't fit too well on your head. The mike boom and its attachment to the headpiece just doesn't seem to be the best arrangement that could be worked out. It's a lot superior to others that we've tried, though.

COLLINS

I take the lightweight headset apart. The piece that goes around over your head I throw away. Then I attach the microphone to my collar somehow with an alligator clip. I take the long-eared tube and tape it to my ear with a piece of adhesive tape. That's the only way I can stand it. If I put it around my head, it drives me crazy after a couple of hours; not to mention falling off all the time.

ARMSTRONG

The only difficulty I noted, because I like the lightweight headset myself, is the fact that the mike boom and the headband are a quick-disconnect arrangement, which is continually disconnecting. I'm sure there was some good reason for that. It may be desirable for some people, but I would

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ARMSTRONG
(CONT'D)

much rather just have that thing firmly connected in the proper location and leave it like that.

ALDRIN

I used the molded earpiece inside the COMM carrier in the LM through activation and power descent, but it became so uncomfortable that, after we were on the surface, I removed them and continued the remainder of LM operation without them. They did increase the volume during the time that I had them in, however.

20.10 RESTRAINTS

ALDRIN

I think I've already mentioned that, in the LM, the LMP's restraint system tended to force you forward and to the right and required leaning back to the left to maintain balance. This was a little bit disconcerting.

20.15 CAMERA EQUIPMENT

ALDRIN

The only possible malfunction that was observed was with the LM 16-mm camera. Evidently, it worked properly, but it didn't seem to give the proper indication. Initially on connecting power, the green light came on and, after 10 to 12 seconds, it went out. However, once we started taking pictures subsequent to the initial turning on of the camera, whenever the power came on, the light came on and stayed on throughout the time the power was applied to

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the camera. So it didn't really give an indication as to whether frames were being taken except when you observed the light to be blinking.

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21.0 VISUAL SIGHTINGS

ARMSTRONG Most of the items in Section 21, Visual Sightings, have been previously reported.

21.4 TRANSLUNAR AND TRANSEARTH FLIGHT

ALDRIN There was only one minor observation returning from the Moon. Looking back at it, at a time after Mars had passed behind the Moon, there was one time period where I imagined that the image of Mars was coming from a region where it couldn't come from, because it was in a dark portion of the Moon. This obviously was an optical illusion of some sort.

ARMSTRONG I suspect that it was, in fact, just immediately adjacent to the horizon.

ALDRIN We must have looked at it immediately after it had come from the back side.

ARMSTRONG Yes.

21.5 LUNAR ORBIT

ALDRIN In lunar orbit, following ascent, we did note and mention to the ground that approaching CDH when the Earth came up above the lunar horizon, I observed what appeared to be a fairly bright light source which we tentatively ascribed

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to a possible laser. That seemed to be the best possible explanation until we were coming back in the command module approaching the Earth and were able to observe something that gave about the same appearance. When putting the monocular on the light source, it appeared as though it was the reflection of the Sun from a relatively smooth body of water such as a lake. I think we've revised our initial conclusion as to what the source of that light was that we saw coming from the Earth. If no one owns up to having beamed the laser toward the Moon at that time, it was more probably a reflection off a lake. I still think it's an unusual phenomenon, at that distance, to see so bright a source of light. In the film, it didn't appear as though this was going to show up at all. The Earth was too bright.

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22.0 PREMISSION PLANNING

22.1 MISSION PLAN

ARMSTRONG First, we can say that essentially the entire flight was flown on the mission plan and the details of the flight were, in fact, in accord with the flight plan.

22.2 FLIGHT PLAN

ARMSTRONG The flight plan was really very well written, and we found very few discrepancies in flight. In terms of system operation, normal housekeeping chores, pre and post, sleep, checklists, burn reports — all those things were included; we very rigorously followed all the instructions day by day in all 135 pages.

COLLINS A good flight plan; a lot of hard work went into it.

22.3 SPACECRAFT CHANGES

ARMSTRONG Spacecraft changes were relatively few in the final stages, although there were numerous replacement items. Fortunately, there were not too many configuration changes in the preflight phase.

22.4 PROCEDURES CHANGES

ARMSTRONG There were relatively large numbers of procedural changes filtering through this system daily, right up until and during flight. Some of these procedural changes were

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relatively significant; others were very small. I can't say how it compares with other recent flights in the same time period, but it was our impression that the procedural changes were excessive and indicated that generally we hadn't completed our preflight planning as well as we would like to have done and in timely enough fashion for a mission of this consequence.

ALDRIN

What this means is that a good bit of the training had to be developed. It had to be devoted to the development of these procedures in the new areas that we had in our mission.

COLLINS

I think, in general, if the crew wants to make changes to their procedures, they should be discouraged from making any unnecessary changes. The time period when the crew really should be in the change loop, I think, is fairly early in the training cycle, a couple of months before launch. During this time period, from the command module view point, I found it difficult to promote changes. I found that there was a considerable time lag between my requesting a change and my seeing a new checklist or a new rendezvous procedural page or what have you. It ran on the order of several weeks. This is

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COLLINS
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several months before the flight that I'm referring to. This is the time when I was trying to get the rendezvous procedures optimized. In the checklist world, I was trying to get obvious mistakes corrected, trying to do this early in the game. It was very discouraging, because the results frequently came back not exactly with the changes as I had intended them; and there was a considerable time delay between the time that I requested the change and the time that I saw a new piece of paper in my hand — on the order of perhaps 3 weeks. Now late in preflight, everybody got all hyper and they got streamlined. A week or two before the flight, when I desperately wanted not to make changes, the system was all for it. If changes were required, from the day you requested it to the day you had a new piece of paper in your hand was more like a day or two. Now, that's the kind of service that we needed months before. It would have saved a lot of manhours of work in the long run to have a fast-response system early in the game; let all these changes reverberate throughout the system, go to the contractors, and come back. It ended up that when the quick response was needed it was not there, and late in the game, when we didn't want to make changes, everybody

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was hovering around us saying, "Well, how about this? Do you want to change that? Do you want to change the others?" In general, it's the same thing I think we had in the Gemini program; that is, in the final phases of training, we really had superb support and help. If you could drain off a little bit of that and give it to that crew earlier in their training cycle, I think things would, in the long run, be a lot more efficiently handled. It's a case of not having enough help early and having too much late in the game.

Well, I'm sure I only see a very narrow little section of the total operation. Just from my parochial viewpoint, it would appear that if you have a glob of help this big, instead of putting all of it on the next flight to fly, you take a little chunk of it off and give it to the following flight.

ARMSTRONG

You wouldn't need so much help at the end. You wouldn't have such frantic finishes.

ALDRIN

I think we've already commented on a specific change in the mission profile; namely, the change in the CSM orbit from circular to elliptical and the two effects that had that I don't believe received enough preflight

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ALDRIN
(CON'T)

attention. One of them was the change in the radial component of the CDH maneuver from a small value to a significant value. Our burn had an 18-ft/sec component. The other effect was the range-rate values that we had despite the fact that it was a nominal insertion and a nominal trajectory approaching CSI. The range-rate values were outside the limits of the backup chart, rendering that solution useless.

22.5 MISSION RULES

ARMSTRONG

I think that we had a good working relationship during the formulation of mission rules; essentially those rules are worked out at the working level sufficiently early that we had very few head-knocking sessions on disagreements on the rules. We flew with rules that were generally agreeable to everybody.

ALDRIN

I think the Flight Operations people were most cooperative in working these things out and explaining the various peculiarities to us.

ARMSTRONG

It is somewhat of a problem for the crew to know the mission rules well enough to fly the flight according to to rules. It's a very extensive and detailed document, and, fortunately, we didn't have any trouble. In

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time-critical phases, it's quite a problem to recall all the rule combinations that, in fact, have been carefully decided preflight. We used some gouges and did take some short, streamlined versions of the mission rules (the significant ones) on both the CM and the LM, should there have been any problem when we did not have COMM available to discuss the situation.

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23.0 MISSION CONTROL

ARMSTRONG There's very little comment there. It worked well. Data transfer from the spacecraft to the ground worked well. We were well advised of our status and consumables and so on. Updates went as per simulation. There were some real-time flight plan changes during the flight which I think always could be accommodated.

COLLINS I just thought, in general, that we got outstanding support from all four of the teams involved. I thought that, in general, everything was beautifully worked out, and I don't think we ever really had any serious disagreements before the flight or during the flight.

ALDRIN Well, I think the CAP COMM's are to be highly commended for their very detailed understanding of every particular phase of the mission and just what was going on inside the spacecraft. I think they did an outstanding job.

COLLINS I do, too. I think they did a superb job and so did all the rest of the team. I thought we had just outstanding support. I couldn't be happier.

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24.0 TRAINING

24.1 CMS

COLLINS

I think the CMS, in general, was an excellent simulator. Its weak point is its visual system. Some improvements were made during the course of our training. For example, some of the Apollo 10 photographs were put into the sextant and telescope visual to enhance P22 training. Various adjustments were made to the transposition and docking, the window display, the model was tweaked up, and so forth. I'd have to say, though, still in general, that the visual is the weak spot in the training, and P22, P23, transposition docking training suffers because of it. The crew station was well equipped. It was brought up to the 107 configuration after the flight of 106. We inherited all the various stowage compartments, or most of them I should say, so that during the last 6 weeks or 2 months' of training, the crew compartment quite closely resembled the interior of the spacecraft, closely enough. If I had any changes to make to the CMS, I would spend the money on trying to improve the visual simulation. I think the people who work most intimately with the CMS are those that are most aware of its visual shortcomings. They understand the changes that have to be made. It's just a question of

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getting the money pumped into the system to make the necessary design changes. The availability of the CMS was quite good. It did bomb out a time or two, in which event the CMS 3 was usually made available for our training. I think that the crew of the spacecraft next to fly should have the right to use the other simulator to keep the mission simulation schedule on an even keel. I don't think you should just arbitrarily kick the next crew off on any old day when your prime simulator bombs out. However, during times when Mission Control is on the line, I think either simulator should be made available depending on which is working better for the crew on the next vehicle to fly. That's about all I've got to say about the CMS.

ARMSTRONG

Well, I'd like to make a couple of comments here, and it applies both to the CMS, LMS, and all our simulations in general. First, I'd certainly agree that the strongest shortcomings of both the simulators is the visual. It's able to do a reasonable job on the stars, star patterns, and the things necessary for optics for platform alignments. Beyond that, the abilities of those half-million-dollar window extravaganzas is negligible.

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There are a lot of areas that could very well stand an improved visual simulation for training.

ALDRIN

I think one of the biggest drawbacks of the visuals is the lack of illumination coming into the spacecraft from the window from either the illuminated surface, or more important, from the effects of the Sun shafting coming in.

We're always operating in much darker conditions inside the simulator than those that actually existed in either the CM or LM.

ARMSTRONG

Now, the second area that suffers in fidelity is probably less important, but it's factual. That's the area of all the gas and fluid systems in the spacecraft. Our simulators do a good job of electrical electronic simulations but do an absolute zero job when it comes to what do valves do; not in how they reflect in the gages, but how they actually affect gas flow around the spacecraft through valve sounds, water flows, and how to operate those devices. Apparently it isn't mandatory, because we managed to fly the spacecraft and operate those systems without ever looking at a simulation of them. I think it is a fact that we do not have a simulation of anything like the glycol loops, or the suit loops, the effects on suits, of operating valves in the spacecraft in both CMS and LMS; things like

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(CONT'D)

REPRESS, cabin circuits, and so on are just absolutely not represented except as they are reflected on gages, which really is a relatively small part of the operating of fluid and gas systems. You want to talk a little bit about the switch?

ALDRIN

There were several changes made between LM-4 and IM-5, and I think the LMS was a little bit late in getting some of these modifications such as some changes in circuit breaker locations, the LCG pump circuit breaker, the radar GYRO switch. We did get these in, I'm not sure the exact timing, something on the order of 3 weeks, something like that, before flight. It would have been nice to have had that package of modifications completed sooner.

ARMSTRONG

They were installed essentially coincident with the time period when you should essentially have simulations completed and just be brushing up on that one. I think, generally, the availability of both simulators, with the exception of a few days when they were unavailable, was good. We could generally depend on having one of the two CMS's and the LMS available to us for training. Very seldom did we have to sit around and wait for the simulator to be ready. The fidelity wasn't as good as you'd like, but their availability was good.

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COLLINS A high degree of availability was absolutely mandatory on our training cycle. If we had poor to bad luck with the simulator availability, I don't believe we could have flown the mission of the 16th of July. I think it would have been unwise for us to attempt flying the mission on the 16th of July with much less simulator time than we actually had.

ALDRIN What we're really saying is that both the IMS and the CMS were the key items of training, and so much of all that we did depended on their operation.

COLLINS That's right. When the system really committed to a July launch, I'm not sure when that was, but my impression was that that decision was made fairly early, although not officially.

ARMSTRONG It was soon after the 10th.

ALDRIN Yes.

COLLINS When that decision was made, a very vital part of it was the fact that the assumption was made that those simulators would work properly and that we would have a high degree of availability for the remainder of our training cycle. If we had stubbed our toes a few times along the way, I

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COLLINS
(CONT'D)

don't think we'd have been prepared to launch in July. I think we were lucky. The simulator availability was up, and we were able to grind away hour after hour of good fruitful training, particularly in the mission SIM's with MCC.

ALDRIN

I think the visual — we may be knocking it a bit too much and not pointing out some of the good features. I think it did quite a good job in the pre-PDI observation out the window of making uses of films that were taken on Apollo 10. I thought this was incorporated into the system in a very, very efficient and very well-reproduced fashion.

ARMSTRONG

The new L&A, with the new model of landing site 3, certainly was a gigantic improvement of the previous lunar surface visual.

ALDRIN

Yes. Unfortunately, it lost its usefulness at about 100-foot altitude. Isn't that right?

ARMSTRONG

Yes.

ALDRIN

So it could not be used for the very final manual phases of the touchdown. Again, most of the final phase of descent was restricted to the presentation made in the

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left window, the one that was in the right window was not a correct presentation, because it essentially was the same view that was out of the left window, which put it off the angle by some 50 or 60 degrees. Now, it would have been nice to have had a better visual presentation in the right window. I wouldn't put it in the mandatory category because at this stage of the game I don't think that the roles employed by the crew members required a high-fidelity visual in the descent phase for the LMP. I think his tasks were more occupied monitoring onboard systems, relaying the information that was displayed by the computers, and by the radar system as an assistant to the Commander.

24.3 INTEGRATED SIMULATION

ALDRIN

When they worked, there was no doubt that they were extremely valuable. We did lose a fair amount of time because of computer problems; not the spacecraft computers, but the computer that ties the two together.

ARMSTRONG

In this type of a mission plan, of course, the integrated simulations are a very vital part of the training and not just the training. They are a vital part of the procedural development and checklist development that's required to gain the confidence level that you have to have to

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(CONT'D)

begin a flight of this type. In general, I think that we performed a lot of integrated simulations, and they were, in general, very beneficial.

COLLINS

I don't think we performed too many, I think we had about a minimum number. I think, perhaps, we spent a little more time than we should have on launch/launch-abort SIM's and maybe not quite as much as we should have on lunar ascent SIM's.

ALDRIN

Yes. I agree that it was satisfying minimum requirements, and we certainly could have used up to double the number of integrated simulations.

ARMSTRONG

In general, the simulations where both vehicles were airborne were pretty good. Simulations where we had one on the ground and one on the surface were probably less productive and less like the real case. I doubt that P22's and things like that ever really worked well enough in the simulator to give you a good understanding of that part of the problem.

COLLINS

Yes. That's true.

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24.4 NETWORK SIMULATIONS

ARMSTRONG When we talked about integrated simulations, we've been also talking about network simulations because far and away the majority of our integrated simulations were performed as a part of the network simulations. As a matter of fact, in the final months, prior to launch or perhaps six weeks prior to launch, the great majority of our time was spent on network simulations. Such a large percentage was spent on simulation with the network, as a matter of fact, that we had difficulty finding time to do simulations that were not covered by the network simulation.

COLLINS That's true.

ARMSTRONG I would guess that about 60 percent of the days were covered with simulations with the Mission Control Center.

COLLINS Again, this is the sort of thing where we seem to fight our way through these flights one by one and the SIM's come very late in the training cycle. It would appear to be very valuable that some of these first SIM's could be moved up in time so that we don't have this last minute cluster of them. It makes you nervous from a number of viewpoints. First, you don't really have as much time

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available to putter around with those things which you know you're rusty on and you need training on. Second, the monkey's really on the back of all the electronics people to keep those things running, and you really have to keep them running, and you've got to go through successful day after successful day or really you will not meet what you set as minimum training requirements. I think there is a lot of pressure there on a lot of people at the end to keep those simulators running. There's pressure on the crew and on the maintenance people, and the pressure all around because we delay those SIM's too late in the game. The reason we do delay them is that the total system, the Center, is really only capable of facing up to one flight at a time.

24.5 DCPS

ARMSTRONG

The DCPS was used only for launch, launch abort, and TLI simulations. Although we were unable to afford the time to do many of these as we liked, the simulator worked reliably, and the procedures developed there were very useful. I think it's probably appropriate to say that as the flights have progressed, the launch abort procedures have fortunately become more and more streamlined and simplified. I think at the present time they are in

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(CONT'D)

very, very understandable and rational form. It's an easy job for the left-seat man during launch to understand those procedures and be able to implement those irrespective of other situations.

24.6 LMPS

ALDRIN

Well, I was a little disappointed in the variety of abort cases that the LMPS could handle. We looked at the DOI aborts. Primarily, it was a rendezvous trainer. Starting at insertion and for nominal rendezvous cases and then a good bit later in the game, we were able to pick up certain selected abort cases. But, as I say, I was a little disappointed in not being able to run through a wide variety of different cases. There were potential cases that could have arisen.

24.7 CMPS

COLLINS

The good thing about the CMPS was that it could investigate a number of dispersed rendezvous cases. The bad thing about it was, first, as far as Apollo 11 was concerned, we got caught in the middle of a move from one building to another, and the timing was extremely poor. It made the CMPS not available early in the training cycle when we could have made very good use of it. At that time, the CMS's were really not available. Late in the training

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cycle when the CMPS became available, it was of little or no value to the crew itself. It was of value to other people, but to the crew itself was of little or no value, because we were then spending all our time on the CMS and had no time to devote to the CMPS. So it was just a masterpiece of poor timing for Apollo 11, and Apollo 11 comments I am sure won't carry over to other flights. The bad thing from a technical viewpoint about the CMPS is that the computer is a sort of an idealized simplified mechanization of the real computer, and it was always several iterations behind the latest MIT math flow. It never quite worked like the real computer worked. I guess during the rendezvous this is an important factor.

ALDRIN

I think the same thing applies to the simulation of the LGC. It was considerably limited, and there were many little tricks that we employed that you could exercise in the LMS. When you try and work them in the LMPS, the computer wouldn't respond properly, and to that degree, there was a certain amount of negative training because we'd have to establish other procedures, other work around techniques to come up with the same information.

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COLLINS I'd like to emphasize that what I've said about the CMPS and its shortcomings is not the entire story. I was talking about the actual crew training on the CMPS. Now, above and beyond the crew training, the CMPS was used as a procedures development simulator, and the McDonald Douglas people spent a lot of hours looking at various trajectories and various dispersed cases and also on various abort modes. The thing was of great value in putting together my solo book with all the dispersed cases and all the abort possibilities. So I'm sure it was of great value. It was just that because of poor timing it was of very limited value as direct crew training.

24.8 CENTRIFUGE

ARMSTRONG LMP and CDR had participated in centrifuge training in preparation for Apollo 8 and chose not to repeat that.

COLLINS I thought that half a day on the centrifuge was useful. I don't think it's mandatory. I think you could go ahead and fly the flight safely without any centrifuge training at all, but I think that to do a couple of entries in it is worth the time. It's well worth the time spent there.

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ALDRIN

That was good that we had done that on Apollo 8. I thought that was well worth the time.

ARMSTRONG

The launches were never simulated in either case and I don't see any requirement for launch acceleration.

COLLINS

The only hooker there is if you get into these abort cases where you're pulling horribly large numbers of g's for great lengths of time. We just ignore those, and I suppose that's probably all right. Somewhere in all our background, we've had Johnsville centrifuge runs up to 15 g's and things like sustained peaks over 10 g's, and I'm not sure that the crews that are coming in now have had any experience like that. I think one time is worth it to see a very high g spike and to see a fairly long period of time at a moderate g of 10 or thereabouts. There's no doubt about it that there are certain little tricks about breathing that would be nice to know and to remember in the unlikely event that you did have one of these high g aborts. So I'd say that a general background training is worthwhile. Having that under your belt, I think half a day for a specific mission training of entry would be more than adequate.

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24.9 THE DOCKING SIMULATOR

ARMSTRONG The docking simulator was used very little. Some simulated LM dockings were performed in that simulator, and in as much as that is a secondary docking method, we felt that was adequate. Had I more time available to prepare, I probably would have spent somewhat more time on that than I did. As mentioned earlier in the debriefing, the shortcoming of that simulator is that it doesn't provide any of the simulation of postcontact dynamics. That is, of course, the area where we ran into a little problem, so scheduling of that by the training people is probably warranted.

COLLINS I think the docking trainer should be command module active rather than LM active. I don't know how much it would cost to convert it, but the thing is going to sit over there and cost money for its upkeep and people to run it and all that. It's probably worth a little extra to make it command module active rather than LM active.

24.10 RDS

COLLINS Well, I feel the same way after the flight that I did before about Langley. That is, if Langley is up and

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COLLINS
(CONT'D)

running, it's well worth the trip to Langley to make use of it. But I don't really think that you can put that simulator into mandatory category. Once it's dismantled, I would say leave it dismantled. There is no firm requirement; it's not mandatory to look at the Langley simulator. It's useful, it's real, it's full-size, it gives you a good out-the-window display. Although it is hydraulically operated, its control system response is very close to the real thing, and if it were in existence, I'd sure take advantage of it again as I did in the past. You guys flew that, didn't you? What do you think?

ALDRIN

No, I didn't fly it.

ARMSTRONG

Not recently.

24.11 FMES

ARMSTRONG

We didn't have the opportunity to participate. I'm quite sure that there were many areas of interest, that would have been valuable for the crew to look at in the FMES. We could not afford the time, and with the unpredictable schedule of the FMES, it was just impractical for us to try to incorporate that into the training period.

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COLLINS

That's the same with the North American evaluator. I tried up until several weeks before the flight to find time to go out to the evaluator and look at sort of a summary of what they found in their Apollo 11 verification work. But it just didn't work out, and I put it in the "nice to have" category rather than the "mandatory" category. I think you'd learn some things from it, and it would be a good crosscheck on the CMS, but I don't think it's mandatory that the crew participate in the evaluator.

24.12 EGRESS TRAINING

ALDRIN

I don't feel that the tank egress exercise is worth the time. It seems to me it can go right to the Gulf. We understand the procedures well enough, and there are no difficulties from a safety standpoint that really warrant exposing the crew to both the tank and the Gulf.

ARMSTRONG

The Gulf exercise is relatively productive for the amount of time it takes. It's a half day exercise, and I think that it was well organized for us. For the couple of hours' work that it takes, you probably get a good bit of confidence in your ability to handle the spacecraft in the water, and you're obliged to do something in that regard.

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COLLINS

Yes, I agree. You probably delete the tank, and I think, oh, it's a pleasant ride out on that boat. You're sleeping or sitting around doing nothing. I think probably if you're going to get the most out of it, you could precede the Gulf work with a couple of lectures and briefings on the boat on the way out on what you are going to do and how to run through all this stuff and the whole schematic on the postlanding events system and maybe a few words on the survival kit. If you delete the Stable II training in the tank, then that time could be spent on briefing, on some other precautions, such as the no-no's involved in Stable II egress. I think that would be a more productive day if it were arranged that way. On the other hand, I enjoy sitting around in the boat. It's relaxing.

ARMSTRONG

Pad egress and mockup egress have to do with preparing for an emergency in the spacecraft on the pad. This is required for the chamber operation for safety in the chamber. By the time you get through that, not very much additional is required for the spacecraft, itself, on the pad. I don't think we spent excessive time in that area, though.

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ALDRIN

I do think you want to accomplish some of these exercises with flight gear because the training suits are used so much, and fasteners and connectors always seem to work a lot easier. It's a good exercise to run through at least once under requirements to move quickly with the flight hardware.

24.13 FIRE TRAINING

ARMSTRONG

It's valuable, if you do have a fire and have to use it. Other than that, it's like buying insurance. If you never use it, of course, it's just a time expenditure that was nonproductive. I've no objection to that fire training.

24.14 PLANETARIUM

ARMSTRONG

We had a very limited planetarium training exposure. It's primarily due to the fact that we just didn't have the time to look into it in more detail. We had relatively extensive planetarium flight related work on previous flights. Our work was limited strictly to the flight plan itself and work in the flight: things that could be learned in the planetarium that would apply to the mission plan, stars selected for alignments, what could be seen from the lunar surface, what constraints due to certain lighting conditions and locations

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(CONT'D)

of planets, those sorts of things. We did it relatively early in the training cycle to get a basic understanding of what our geometric situation was, and that was probably worthwhile.

ALDRIN

I think it was. It's useful in a general sense, because you might be able to get some early information on the planets. The simulator doesn't have any representation of the planets. I think most of the specific navigational use of the stars and the star field can best be done with the existing CMS.

COLLINS

I think one trip to Chapel Hill for a training cycle is useful.

ARMSTRONG

That's what I think. The geometry for fixed mission launch time is pretty well fixed on a lunar mission. That is, once established in a launch date, the entire astronomical geometry is fixed. A good understanding is very useful. It influences a lot of things later in the procedural developments, so that session is probably worthwhile. It can be improved by having a mission planner that understands the geometry and the constraints of this launch date involved in the planning of that

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(CONT'D)

training session. We tried to do that, and we really didn't get as much out of that aspect of it as we would have liked.

24.15 MIT

ARMSTONG

I want to talk about MIT and, in general, in our flight, this was restricted to understanding of the programs and program changes, as in the software end. The hardware was pretty firm at the time and we all had a fairly good understanding of the hardware prior to this training cycle. The understanding of the program and program changes, however, is one that unfortunately takes a lot of time. It takes a number of separate sessions in smaller groups throughout the cycle. I really think that rather than one big 3-day session of a review of the programs and so forth, it would be better to have a number of smaller sessions interspersed at various times in the training cycle so you could limit yourself to just one phase of the mission at a time.

COLLINS

I spent as long as 5 days, not on this flight but on others, sitting in a chair at MIT listening to a chronological description of the math flow, and it drives me crazy. By about the second or third day, I'm just saturated; it's like filling up a teacup with a fire hose.

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COLLINS
(CONT'D)

There has to be a better way of doing that than just going to MIT and sitting for days. Maybe if they are broken up like you say, it will help.

ARMSTRONG

This is a difficult area because various people assimilate information differently. I get absolutely nothing from 2 hours of going through logic diagrams, while other people find that very informative. I much prefer going through the operator's checklist and trying to understand each step in the operating checklist, what that does, what information is being displayed, and how it's being processed, than going through endless software loops on a diagram.

ALDRIN

Yes. Until you're related to specific-use situations, it doesn't mean very much.

ARMSTRONG

You have to understand the basic thing and go do it in the simulation; then you can understand better some of the details, why it's done this way, and what options are available to you. Just to spend long days in reviewing hoards of GSOPS and things like that, in my view, is a very unproductive session.

ALDRIN

We've gone over programs such as P20 many times, and I still can't recall all the logic flows of different paths

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ALDRIN
(CONT'D)

that the computer is taking in acquiring radar lockon. I think, in a sense, our checklist may suffer somewhat in that it doesn't help too much either in this respect, in covering the various ways that you handle abnormalities in acquiring radar lock. Certainly, the time spent in going over all the logic flows wasn't particularly productive.

24.16 SYSTEMS BRIEFINGS

ARMSTRONG

In general, we didn't have long courses of systems briefings. We chose to have an expert on a particular system come in periodically and review that system on an available basis. This worked all right, but in my own case, I felt that by the time we got within 2 months of the flight, we still didn't understand some of the systems or hadn't gotten around to understanding them in the depth that was required. I don't know how to get around this. This was the problem in our flight that was just due to the very tight training schedule that we were on. There just wasn't time to do all the things in the order and in the depth that you wanted.

COLLINS

I have one concrete suggestion for these systems that centers around CMS-1. CMS-1 is the simulator where the crews get most of their systems training, because they're

MSC

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on CMS-1 before they go down to the Cape and get the more mission-oriented training. CMS-1 has some very good instructors. It uses a different system than CMS-2 and -3. CMS-2 and -3 have people who are trained across the board in a rather shallow fashion. CMS-1 has people who are trained in a narrow area but in depth, and they have some good people. One flaw is that the CMS-1 instructors know how the system is designed and of what it is capable, but they have no more idea than a rabbit of how the equipment is actually used in flight. On a few occasions, I have had people from FOD EECOM's to come over and sit in on CMS-1 briefing sessions, and it ended up being more of a briefing session for the CMS-1 instructor than it was for either me or the FOD people. I think there should be some way at MSC to get the right hand and the left hand together, to get the CMS-1 instructors up to speed not only on the basics of their system and its capability but to go one step further and get them into the Control Center, get them to know the EECOM's, and get them to further understand how the equipment is actually used during the course of a flight. Then I think they'd be much better prepared to present to the crew those things that are really important and not trivia along with the important details. Maybe there are pitfalls

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COLLINS
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there, but I have the feeling that I got a hell of a lot out of CMS-1. I liked CMS-1 and the instructors. It was sort of the backbone of my systems training. But I think it could have been a hell of a lot better if it could have been integrated into more of a real-world approach. If those people were familiar with the everyday operations of Mission Control; the downlink; what they have on telemetry; how you use the water boiler, not how you could use it but how you really are going to use it, that would have enhanced that training a lot.

ARMSTRONG

We had only a few hours on the launch vehicle, which is probably about right. It's fortunate that, because of the high reliability of the launch vehicle, we haven't had a requirement to know in depth a lot of alternate switches. In most cases, they are available to you anyway.

ALDRIN

Not too much you can do about them.

ARMSTRONG

There are some things, particularly in the S-IVB relight, that it's important to understand very well. If it works perfectly, it's going to run right in spite of you. But if there are abnormalities, it's very good to understand what the effect of those are. So some amount of time is required there. I think we hit that about right.

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ALDRIN I think the DCPS did a very good job in relaying launch-vehicle peculiarities to us.

ARMSTRONG They did. The DCPS people do a good job in that area. They understand. They have kept very close to the launch-vehicle changes, and I think they have really been able to keep us better informed on important things to know in the launch vehicle than our formal Saturn briefings.

24.17 LUNAR SURFACE TRAINING

ALDRIN I think there were enough uncertainties about the one-sixth g environment to warrant the degree to which we used both WIF and the KC-135. Looking back on it now, I don't think the followon crews will need as much as we did. I believe that the more productive training would be with the KC-135. It would be nice to have a better simulation of the surface characteristics. That is the big shortcoming, I believe, of the KC-135. But one-sixth g is relatively easy to operate in. It doesn't take too much detailed training, I don't believe.

ARMSTRONG As far as the use of POGO, I think it's worthwhile. It takes very little time to go over there and train. From the viewpoint of the directorate maintaining the POGO and what its cost of operation is in terms of money, staff,

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all time of cost, esp. Collins

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et cetera, I can't say what the balance is there. If it didn't cost anything, there would be no question that the little bit of time that it takes to go over there and get that kind of experience is worthwhile. It's not mandatory. The KC-135 is unquestionably the best simulation of one-sixth g. It's got certain limitations as we all know. You can't do very much, and it's very expensive in terms of the amount of time it takes you to get a little practice.

ALDRIN

You're probably not going to remember them. I think the best time to do that is just at the beginning of the EVA.

ARMSTRONG

The one-g walkthroughs, of course, were the basis of our timeline planning. I don't see any way of getting away from that. You're going to do a number of those one-g walkthroughs, and you're going to develop your timeline and the procedures. There isn't another way to do it right now that's a good way.

ALDRIN

Yes. That's the only way to do it. You can't sit down.

ARMSTRONG

It's well worth it. We would like to have been able to do a few more had we had the time. I think that we do need to improve our facility for that job. We need to have a better LM, more accurate simulation of the LM.

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We need a better and larger area to work in. We need more topography and variations of environment to work in so that the simulations can be as good as you can reasonably afford on the ground. I think ours was less accurate in terms of its fidelity than we should have had to properly plan that. We should have as much flight-type equipment as we can in those exercises. It's going to result in an increased productivity of the time you spend in EVA.

ALDRIN

I think the Sun position relative to the spacecraft is extremely important. There are so many things in the EVA that are completely dependent upon the lighting conditions that you have, such as placement of experiments and the photography. We were prepared to do it in one fashion, assuming landing straight ahead. With little variations of that, we generally knew how we were going to approach them, but it was going to be a real-time decision for the most part. With the small amount of yaw that we had, it did perturb our operation to some degree. I think that the one-g walkthroughs ought to look at specific variations in LM orientation and touchdown.

ARMSTRONG

We didn't do much in the way of field trips. We did one geology field trip. We never could afford one which we

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thought might be particularly valuable for its scientific
return.

ALDRIN

I felt for the most part that the trips we went on
suffered a good bit from lack of realism. Maybe we just
didn't get into this latter one, that we missed, soon
enough. I think, based on some of the information that
we've acquired on this flight, we'll be able to make many
of the field trips a good bit more productive.

I think both SESL and the 8-foot chamber are valuable.
It's hard to say that they are required. They do give
you that additional confidence in the flight equipment.
It would be nice to be able to operate in both of them,
for example, with the OPS, and not have restrictions as
we had in the SESL in not being able to use it. I'm
not sure that the thermal aspect of the SESL tests is
needed.

ARMSTRONG

Yes. It proved to be noninformative, which I guess was
good, because it said we didn't have any problems. I
agree with Buzz. The confidence that we got out of that
was very good. I'm glad we did it. I'm glad that we
worked with the flight equipment in there and, in a
cursory fashion at least, as tests rather than walking

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up and down on a box. Not that it really taught us all that much. Again, it was just a confidence builder, and I think that we could probably do less in the future. It is important, however, for anybody in a surface activity to have a high degree of confidence in his ability to operate his equipment. That is what that gives you.

ALDRIN

In the SESL, I think it was more important to be exposed to the lighting than to the thermal environment. It was the only place that came fairly close to duplicating the wide variation of lighting conditions.

ARMSTRONG

Our briefings on lunar surface training were more give-and-take sessions on planning the various procedures and deciding the most efficient way to use our surface time. That's consistent with many other areas of the flight, I guess.

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24.18 CONTINGENCY EVA TRAINING, KC-135, WIF, ONE-g WALKTHROUGHS

ARMSTRONG We did contingency transfer in the WIF and went through some procedures with that group. Since we didn't have to use it again, it fits in the insurance category.

ALDRIN There is such a wide variety of contingency situations that can come up. You can't train for all of them, and I think you have to cut short a few of the available possibilities and just say that if you have to face that one, you're going to take the time and work it out in real time. There are a wide variety of exercises - one PLSS; one OPS; two PLSS, sometimes with OPS and sometimes without; and transfer of hoses through the tunnel. You just can't train for all of them. Somebody has to sit down and try to work out procedures. I think you do need to take a good set of inflight contingency procedures that will handle the cases that may come up.

COLLINS You need at least one good long session inside the command module with all three crewmembers suited to go through where all the hoses are going to be; who's going to plug into what, when, and where; who's going to help who; and what the COMM situation is going to be.

ALDRIN That's true, but doing that in one g is rather unrealistic.

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COLLINS

That may be, but instead of just getting a briefing on where the things are going to be, you ought to see them with your own eyes, particularly the geometry of the thing without the center couch in there, the locations of the hoses, and again, who's going to stand where and who's going to help who plugs into which hose when.  Three men in there with pressurized suits who don't understand what's happening and can't talk to one another would be one hellacious mess. 

24.19 MOCKUPS AND STOWAGE TRAINING EQUIPMENT

ARMSTRONG

The mockups and storage equipment were used extensively and, in general, they were satisfactory for developing the procedures. I think the place where they are short is particularly in the area where you're making connections to and from the spacecraft, operating several different life-support systems such as the EMU, OPS, spacecraft suit loops, and things like this. It's very important that you operate all those valves per equity and know why you are operating them in that manner. Our mockups do not do that. They are just knobs and you just do them. It's important to know why you are doing them.

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ALDRIN It's unfortunate that operating gear weighs so much in one g. It's virtually unbearable to have that piece of hardware on your back for a long period of time.

ARMSTRONG I think we have a lot of complex flights ahead of us in main-line Apollo and I think there are enough of them, enough possible contingencies, and enough training yet in front of us that it would pay to upgrade this area. Many people still have to learn all that hardware; its whys and wherefores.

24.20 PHOTOGRAPHY AND CAMERA TRAINING EQUIPMENT

COLLINS I just think that gear ought to be available earlier. It's one of the things you can get done or at least get started on 3 or 4 months before the flight, and yet it's not available. It's another one of those late-arrival categories. I'm not sure whether it has to do with the quantity of the training equipment or the fact that we have to get one flight down before we can get around to providing for the next one. I think the familiarization with the cameras (taking them home and taking pictures while you're flying around the country in T38's) should be done early and not the last couple of weeks. From the flights that I have been associated with, it seems to me that it's always been the last month when that stuff

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magically appears and they want to talk to you about it and all that; it should be done earlier, I think.

ARMSTRONG

That gear should also include flight fidelity. It should have decals on it; we should be used to seeing the kinds of decals, exposure guides, and things like that that we are going to be using in flight. Those things never show on any of the training equipment. That should be included as mandatory.

ALDRIN

The LM photography is tied to operating in the vehicle in many cases, such as the surface photography with the 16 millimeter attached in various ways to the window bar, to the mirror mount. It looks to me like there is room for significant improvement in this area. I think we got into this a little late in the game. So much of the documentation of a flight depends on the photography. It looks to me like we could use some particular training sessions taking real film with flight cameras and the highest fidelity mockup you can create. I don't know how you would do it really - get the proper lighting conditions.

ARMSTRONG

We had a camera session after we had moved to the Cape, maybe a month before launch or so, where it was quite clear that all the photographic details had still not

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been incorporated into the flight plan, that is, all the thinking that's involved in planning camera placements, the things you want to take pictures of in the field of view possible in that attitude, and lighting on the subject so that you're getting the details. All that sort of thing needs to be worked out by the photo people rather than the crew. It should be done much earlier in the cycle than it is now. I suspect that when we look at all our films, many of them will show that we suffered from not really understanding exposure or lighting well enough over all situations. That's a weak area.

ALDRIN

I think the photography for power descent, power ascent, that sort of thing, should be worked right into the simulations. You ought to activate the camera in the LMS; take films. You're not going to come up with anything, but you get in the habit of doing this.

COLLINS

Somebody with a fair amount of experience and background should really be concerned that the pictures we bring back are of the correct events, and that they have been properly integrated in the procedures. I am sure that there are probably people over there in the photo lab that are vitally interested in that. Yet they're not in any way in the loop and probably properly so. They are not any

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way in the flight-planning loop. If we don't feel like taking a picture or something, or if it doesn't occur to us to get it written into the flight plan, it just never happens. I mean there is really nobody who's responsible for the overall photographic excellence or the photographic planning of the flight.

If we happen to think about it and if we happen to personally ink it into the flight plan, then it will get done. And if we don't, then it doesn't get done.

ALDRIN

That's the way most of the photographic entries are, pen and ink.

COLLINS

Maybe we didn't spend the amount of time we should have studying that photo plan, but, again, I say if the crew doesn't take a particular interest in it and make sure that it's in there, then somehow it just doesn't get in there.

ARMSTRONG

Maybe there should be a responsible person for each particular flight. Maybe there is, but I can't tell you who it is on our flight.

Helmut Knehnel has to run his shop, though.

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What I'm saying is the project engineer should be over at the lunar-surface simulations; he's up at the CMS, he's over at the flight-planning sessions, and he's trying to integrate all these things to assure that the right film and the right camera's in the right vehicle at the right time and it all plays.

ALDRIN

Just as an example, it doesn't seem to be a very professional approach to the handling of the 16-millimeter camera to tape it with a piece of tape in the focus to the infinity position. If you want to get it to stay in that position, put some screws in there to make it retain that position.

COLLINS

I think it's ridiculous that we don't have some sort of automatic exposure control or automatic light control, or whatever you call it. Commercial cameras are available where all you do is point and click and the thing is in the right exposure value. And there are even cameras available that have switches where you can have either a wide field or an average exposure value to give you a broad coverage. For example, if you took black sky against a white booster, it would average out the black sky and the white booster. It would give you the average value that might not be optimum for either one, but it would be

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an average panorama. Then if you wanted to be specific and throw a little switch, which zonks a lightmeter down to a spotmeter kind of thing, you can either point it at the dark sky or point it at the booster. These things exist. It's easy to say, well, you can't qualify them, or the right company doesn't make them, or they're not rugged enough, or they won't pass the salt spray, and otherwise raise barriers. If that had been aggressively pursued, we would have right now in our hands an automatic camera that would take a hell of a lot better pictures than we are capable of taking, and we could have qualified the thing by now. I think that should be done, I really do.

I think they are pursuing it with Hasselblads, but, my Lord, they have been pursuing it with Hasselblads for years, ever since the subject first came up, and I just don't see any results. Yet we do carry great huge spotmeters whose utility is questionable, and we manage to develop and carry those frapping things. That Minolta spotmeter was not used during the flight. I don't know what flights have used it but I'd gladly swap it for an automatic light control in a camera. That 2-pound battery is nothing more or less than a handle crank; I'd gladly swap it for an automatic lightmeter built into the camera.

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I think we really spend our time and our money going down the wrong road in that camera shop. There may be very real reasons why what I propose is impossible, but from what little I know of it, you ought to have the capability just to point and click and get the right exposure.

ALDRIN

I think the importance of documenting events was extremely well brought out in this particular flight in that we were too busy doing other things to tell exactly where we were in powered descent. The film was able to do this, but I think it did it in a marginal way. I don't believe that the mounting and the field of view that it gets in the right window is anything near what it should be to get documentation of the powered descent and the powered ascent. Another example is the problems that we had in docking. I think that that should have been documented using high-speed motion film from the LM. There is just no way of doing it.

COLLINS

I never used the spotmeter in the command module. Did you ever use the spotmeter?

ALDRIN

I looked through it for some interior settings. I put it on the Earth, but I don't think anything significant was learned.

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ARMSTRONG We decided, based on the spotmeter reading, that we were probably one f-stop off when we got pretty far away. We had to open up one f-stop to f:8 from f:11.

COLLINS When was this?

ARMSTRONG When we were halfway out to the Moon, I guess. That's what your measurements indicated. I never used the spotmeter.

ALDRIN I take it back, I never used it. There's no doubt that an automatic device would be far superior to anything you get out of the spotmeter. I take it back, I never used it.

24.21 LUNAR-SURFACE EXPERIMENT TRAINING

ALDRIN I think we did quite a good job in having fairly high-fidelity equipment (solar wind, EASEP package) available. The only improvement I would suggest is that we try and gear it to the type of surface environment. The little problems that we ran into were associated with the interface of that gear to the soil conditions; examples are planting the solar wind and attempting to level the seismometer. This is going to be very true when we start getting into more complex exercises with the ALSEP. To do this on a linoleum floor is almost a waste of time;

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~~I think you've got to do it in realistic conditions by
simulating both lighting and surface texture.~~

ARMSTRONG

It would have probably been better practice to be on a more realistic surface. You probably would have consciously looked into those aspects more than we did on the level surface that we did most of our work on.

ALDRIN

Like the LEC operation, the big difference that you noted was the effects of the dust getting all over the tapes and cluttering up the cabin.

24.22 LUNAR LANDING - LLTV, LLRF, LLTV'S, AND LMS

ARMSTRONG

For the type of trajectory that was required for us to fly (with a long manual flight at the end), the LLTV was a most valuable training experience. Like all simulations, it's primarily a confidence builder to derive the required information from the information that's at hand. In the flight situation, the information that I used in the landing was primarily visual. It was augmented by information inside the cockpit that Buzz relayed to me. I did very little gage monitoring during the final descent, that is, below 300 feet. It is primarily an out-the-window job, picking a suitable landing spot and getting into it. The full-scale simulations are the only ones that do this - the LLTV and the LLRF. I would have to recommend continuing

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them both, at least until we have a few more landings under our belt.

I would suggest that more attention be given in the LLTV to changing your landing spot while you're in the trajectory.

ALDRIN

And how to deviate from an automatic trajectory and smoothly pick up what you want to do in the way of deviations.

ARMSTRONG

~~I believe the LLTV can do that job and do it safely.~~ That means that you probably have to do a few more total trajectories than we did in preparation for this flight. I suggest that a dozen is a desirable number — a dozen lunar trajectories in the LLTV. It takes about half a dozen before you're comfortably flying on a lunar trajectory, and after that, a couple of different deviations to different touchdown areas. The LLRF lighting simulation was quite interesting, but in retrospect, it's not a very good simulation of the lunar lighting situation.

In the flight, you see much more daylight, at least at our Sun angle (10-degree Sun angle). It was much more of a daylight landing situation than the simulation that was

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(CONT'D)

portrayed by the night lighting simulation at Langley Research Center.

ALDRIN

They essentially set up a situation where there was no available horizon. That certainly was available in the actual case.

ARMSTRONG

The LMS new model is really a fine addition to the simulator. If you could afford building a model for Apollo 12, so that their last 2 months of simulation would be going into the Surveyor site, then I think you would get a substantial improvement in your confidence level to get to the desired touchdown site.

ALDRIN

I think this is particularly true if they stick to the objective of going to that specific area. We have enough available information from the Surveyor itself to build that model.

ARMSTRONG

I know that's an expensive item to provide, but our experience with looking at the L&A of Site 3 indicates that you really can get a good understanding of that local area in your many landing simulations in the LMS.

ALDRIN

In looking back on the choices that I made with regard to my participation in landing simulations, I think they were generally correct. I don't think that I suffered by

CONFIDENTIAL

CONFIDENTIALALDRIN
(CONT'D)

not being exposed any more to the LLTV. I think one session at Langley was worth the effort. I concentrated on manual use of the throttle and I think that's probably what future LMP's should concentrate on, also. I think Neil agrees that if we did have to execute a complete manual landing, it would probably best be done by the Commander concentrating on attitude control and voicing to the LMP what rate of descent and what changes he wanted. It appeared to be a very difficult task for one person to accomplish all of these. Whereas, when the tasks were split, and use was made of the instruments to manually control the throttle, and a fair amount of practice was made, use of that good performance could be anticipated by a manual throttle landing. For the most part, this can be done in the LMS.

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24.23 GENERAL SUPPORT: PROCEDURES, SUITS, CHECKLISTS, ONBOARD DATA, ET CETERA

COLLINS

As a general comment, our support was inversely proportional to the number of days remaining before the flight. We had poor support at first and later we had superlative support. I would have traded some of that last-minute support for some earlier support. To be more specific, early in the game, the flight-planning people, and the checklist people, and the command-module rendezvous-procedures people worked for three different bosses and lived in three different worlds. It was not until late in the game that John O'Neill was given the overall power and you could go to John or somebody he designated and say, "Look, I've got this problem. The checklist says one thing and the flight plan says something else and the North Americans have never heard of either one of them." That would get squared away. But early in the game, it seems to me that the checklist people sort of pointed the finger at the flight-planning people who responded by pointing fingers in return, and a lot of time was spent, you know, looking for a left-handed monkey wrench. You sort of wandered up and down the second floor of building 4 trying to find somebody who would really take the time and be interested in researching the problem and coming up with

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COLLINS
(CONT'D)

a procedure technique. Late in the game, it was all
 amalgamated under John O'Neill and it worked as I think
 it should have worked from the beginning. I don't
 understand the breakdown in FCOD; I don't understand
 Ernie Dement's bailiwick as opposed to the flight-planning
 world. It seemed that much of the time, they were
 working at cross-purposes and it seemed like - I guess
 they get negative vibrations from the checklist world.
 I guess I have to say that I don't understand their
 problems fully and perhaps they don't understand my
 problems, but I don't enjoy making changes to procedures.
 It seems like the crew only does that when they feel there's
 some good need for it. And yet the checklist people seem
 to have the feeling that other flights have gotten by with
 this procedure and why can't you.

*not in yellow
 pages of phone
 book (not important
 enough).*

ALDRIN

It seems to me that they were unwilling to meet us halfway.
 We had a different job to do, different hardware changes
 in the spacecraft, and different uses to make of the
 equipment.

COLLINS

Maybe it's an unfair comment, but I had the idea that
 their viewpoint was that it was good enough for previous
 flights and it's good enough for this flight, so don't
 bug us with changes.

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ALDRIN

I agree with what you're saying, Mike. I think it's un-
fortunate that there was a division between the checklist
people, the procedures-development people, and the onboard
data. It seems to me that the procedures-development people
should be the ones who also work with the handbook. They
should start it and carry right on through completion,
which includes onboard data. The sooner the crew can start
training with data books that represent the best of your
ability at that stage of training, the more they are going to
to get out of it. We had several new areas, and it appeared
as though we were pioneering much of this in the areas
of procedures development, and also in determining just
how this was going to be presented to the crew and how
you make use of it, and in distributing it around the
spacecraft. We had to make certain decisions, and we
tried one form and then another. I'm sure there are
better ways of doing it than what we settled on, had
many things been done before we got on the scene. I
sure hope that followon crews won't find it necessary
to make big changes.

ARMSTRONG

*Don't use
center
again*

We had five straight flights here on very close centers.
Each crew has been obliged to get some procedures that
work and stick with them, to settle on them close

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ARMSTRONG
(CONT'D)

enough before the flight so that they could remember what they were. That meant to each and every flight, I'm sure, that there wasn't time to sit around and figure out which of several different approaches was the best. We had to take one that worked and stick with it, and in many cases, this resulted in choosing one that clearly wasn't the best, but it was one that worked. The next flight that came along was obliged, wherever possible, to take everything that the previous flight had been able to work out and to go with that. They had enough of their own new things to be concerned with; they had to choose one early that worked and go with it, and not spend too much time deciding which one was best. At the end of five flights here, the result is, I think, that we have the procedures for a lunar mission, about 60 percent of which are not the best ones to use. They are ones that work, but they are a long way from being ideal. We have a little more time before the next flight, and I hope that during that period, we can take the ones that are good and do that work and use those, but not hesitate to change those that are really marginal procedures. That's going to take everybody's cooperation to pick out the marginal procedures and to improve those to the level

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ARMSTRONG
(CONT'D)

you would like to operate with for the rest of the lunar program.

It was an inevitable conclusion of the schedule that we were forced to meet. Everybody had his nose to the grindstone to make the thing work. Now we just have to accept the fact that the inevitable consequences of that situation are that we don't, in fact, have the best of everything at this point. This tends to be a lot of adverse comment, and it really shouldn't reflect that, because the facts are that when you look at it in the overall sense, it did the job. It got us ready to fly and, essentially, we didn't have any big open areas. In the overall sense, it is damn good. I think we tend to be very self-critical in this area, though, because we've all had our hearts and souls in it for a year or so.

COLLINS

I try to put it in perspective myself and say that I thought it was, all in all, an excellent training cycle and very good use was made of our time. We had wonderful support. In some cases, that support came very late, but we had, I think, beautiful support - and I thought it was extremely well worked out, considering the complexity of the things we had to learn. I think that, just from the CMP viewpoint, the proficiency of the CMP (all other

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COLLINS
(CONT'D)

things being equal and they probably aren't) is just proportional to how much CMS time he gets. I thought that I was adequately trained but that I really wasn't particularly polished in any one area. I just didn't have the time to devote to each and every little slice of the pie. I tried to learn all the systems; I tried to learn all the procedures for burns, all the rendezvous procedures, and the navigation, but I will be the first to admit I was far from being an expert in any one of these fields. I don't see how you really can be an expert unless you have more time, more simulator time, to devote to it than I had. I think 400 hours should be a minimum. The only reason I bring this up is that I think some of our training plans say something around 200, 250 hours is sufficient. I don't really think that's true. Speaking from the command-module viewpoint, I don't think you ought to be launching CMP's with less than 400 hours of simulator time. I really don't.

SLAYTON

A lot of your time was spent developing procedures.

COLLINS

There's a lot of truth in that; there were some areas that I had to work but that had not been worked out before. Even if you deleted all those, however, I still

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COLLINS
(CONT'D)

think a lot more than 200, 250 hours is required. You just take the pie and start slicing up the lunar mission; you take all those systems; all the malfunctions; the various mission phases; and the if's, and's, and but's of the various rendezvous. I don't think you could cram that into 200, 250 hours.

ARMSTRONG

I would guess that if you would look at the integrated simulations with MCC and total up the hours there, I would bet it's a significantly larger number than we used to think about per flight. It's because of the many phases of this complex mission; there are just so many phases and each has to be covered in fairly large amounts of time. It's good time, but you really can't count it towards your basic training for the mission.

COLLINS

You should go into those integrated simulations having all the basics behind you; that's just sort of the graduation exercise in a particular phase of the flight.

I just wanted to mention a minor point. I did fly a couple of entry sessions on the FOD's entry simulator, which is an awful-looking little thing on the third floor over in building 30 with a bunch of old Gemini

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COLLINS
(CONT'D)

components and make believe DSKY's. However, it comes with ~~John~~ Harpold, who understands the entry math flow probably better than anybody else that I know around here. I think it is worthwhile to schedule just as I did, maybe two 2-hour sessions on that thing, and I don't understand why the CMS cannot do this. Harpold can crank failures, accelerometers, stuck accelerometers out of SPEC, and little internal failures into that simulator and show you how the computer would handle them - in most cases, how it would fail to handle them - and he has failure modes in his simulator that, so far at least, they have been unable to crank into the CMS. I consider that a worthwhile exercise. It would probably be even better to incorporate those failures somehow into the CMS - he has tried to do it but has been unable to do so. I am not sure whether it is the limitations of the interpretator or what it is, but I think that training was worthwhile.

2ms in yellow pages of phone book

ALDRIN

We haven't covered one category about suited operations. We did a fair amount of suited training in both simulators, and I am certainly glad that we had that amount of time. I can't really identify many areas where suited operations in flight proved to be a big hindrance, but I

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ALDRIN
(CONT'D)

think the sooner you can begin to integrate the total mission package with the data, the type of pens and pencils you are going to be using, where you are going to put them, and where you log all the data under suited conditions, means a higher fidelity training, and I was glad that we did as much suited operations as we did.

ARMSTRONG

Did you keep track of our suited operations overall? We spent much more time in those suits than I ever thought anybody could spend in preparation for one flight. Almost every day for 3 months before the flight, we were in that suit sometime during the day. It would be nice if you didn't have to spend that much time in the suit, and perhaps we didn't, but I guess we had a high degree of confidence in our ability to operate in the suits in the various environments. I think we probably spent more time in the suits than we had to. We did spend much more time in EMU CCFF, fit checks, and stuff like that than we should ever have had to. Seems like we did about 10 of those exercises, and every time they would change a little something on the underwear, or something, they would want another fit check. We bowed to most of those and did them, but I would hope that future flights won't have that much instability in their configuration.

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ARMSTRONG

I think we have a tendency to reflect on what we did and to say that we made the right decision there. I'm not sure that we're in a good position to really judge.

There are several simulation areas that should be improved, some of which we've mentioned before. There is one other area I don't think we discussed, that of optics, and I think it's true in both vehicles, certainly in the LM.

7 The AOT optics characteristic limitations and constraints, such as lighting and sun shafting here and there, are not covered at all in any of our simulations, nor at any time do we actually get a very good opportunity to look through real optics and understand their limitations. I really think that we need some optics someplace that look at the real sky, the real constraints, the real illuminations, side lighting into the optics and things like that so that we can appreciate what you can and can't see. I'm not even sure that anybody agrees with me in this area.

ALDRIN

I agree with that. I think that for the surface alignment, I was quite surprised to find that four out of the six detents were unusable for the surface alignment. I wouldn't have thought that beforehand.

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ARMSTRONG They become very significant on some flights when you start talking about particular little details of the flight. Our mission simulators just don't cut the mustard in this area; they're going to tell you answers that are wrong. I can understand; I just think it's an inherent limitation the way those simulators are built, and I think we need to augment that somehow with some real optics with real lighting. I'm not quite sure what the best way to do that is, but I think you could do it with existing hardware, prototype or test hardware. You could get some of that stuff together and build a special simulation that would give people the opportunity to work, before launch, with some real optics and to mark on some real stars or something.

COLLINS We've done that at MIT to a very slight degree. From the command-module viewpoint, I'd have to say that that sure would be nice to have but I can't think of any situation where a lack of that high fidelity training would make you come to a dangerous conclusion - maybe a wrong conclusion or maybe you might get tricked into thinking you could see the IM farther away than you really could or that you could see more star patterns than you really could.

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ALDRIN

I think if we had to do P51's where your initialized identification would have to be done by the telescope, it would have pointed out many of these deficiencies.

COLLINS

That's right. I thought about saying that they ought to change the characteristics of the telescope in the CMS but I think if you had to do a P51, what you'd do is turn out all the lights inside the command module and, if necessary, put a bag over your head and take the 20 or 30 minutes to dark adapt. Now, you can tweak the CMS telescope to that same level but then all you've really done is wasted a lot of simulator time, because that means everytime you look out through the telescope, you have to wait 20 minutes before you can see anything. That's really all it means. So I don't know. I think in regard to the telescope part of it, the simulator should be left like it is. Concerning visual presentation of the LM as a little pinpoint of light in the sextant, for example, during the rendezvous sequence, that is unreal, but I'm damned if I know how you make that real. I just don't know how you'd do that. Maybe it's doable but that LM as it goes off against the lunar surface background gets smaller and smaller. It is one problem at 50 miles, a different problem at 100 miles, and a

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COLLINS
(CONT'D)

little different problem at 120 miles. To have high-
resolution optics of that type seems to me to be beyond
our capability. I don't know how you'd do it.

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25.0 HUMAN FACTORS

25.1 PREFLIGHT

ARMSTRONG I guess our only activities that fit in preventive medical procedures were disinverting the President and trying to slow down to a reasonable or, at least, acceptable pace in the last week or so. The Cape doctors kept an eye on us that last couple of weeks and I guess we didn't have any complaints there. They did a good job. We got through medical briefing.

ALDRIN I had a couple of conditions come up in the category of dental care and I thought there'd be plenty of time to get them taken care of but there were things that came up at the last minute and we were hard pressed to schedule those in. I would highly recommend that people really take a real close look at their own status as far as those things go and get those things taken care of as early as possible.

25.2 FOOD AND WATER

ARMSTRONG Comparing hunger sensations inflight versus two weeks preflight, I'd just say, in general, that I didn't have as large an appetite inflight as I would on the ground, but I thought it was adequate and I was able to eat enough.

CONFIDENTIALARMSTRONG
(CONT'D)

The food was palatable and all three of us kept our levels up satisfactorily, I think.

COLLINS

My appetite was off on the first 2 or 3 days of the flight, I would say. After that, it was close, if not equal, to my usual ravenous ground appetite.

ALDRIN

I didn't find any difficulty in generating a desire to eat.

ARMSTRONG

I agree with that.

ALDRIN

I think (laughing) in comparison with Gemini, it was good. There were times in Gemini when, of course, we didn't have enough time to do this because food preparation is a very time-consuming task. During the translunar and transearth coasts, there's plenty of time to take care of it; but, no kidding, it takes a long time to get these things ready. If you do have a lack of appetite, the tendency is just to forget about doing a lot of that stuff. But I didn't experience a lack of appetite at all on this flight.

ARMSTRONG

Comments on the taste.

COLLINS

In comparing food during preflight evaluation and inflight taste, I noticed no difference.

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ARMSTRONG Acceptability of the foods. Well, just first make an overall comment that the new foods are significantly improved and welcome additions to the menu. I think, in general, it's a real aid to the normal day-to-day operations in the spacecraft to have pleasant menus and palatable meals.

ALDRIN I think that most people are aware that during translunar coast we did, for the most part, make use of the prepackaged meals. I guess partially because we knew they were more of a low residue and we wanted to avoid any complications with waste elimination that might interfere with the LM activities.

COLLINS In general, I thought the food was at least excellent or better. I thought a lot of hard work went in on the food selection. In general, I thought the quality of the food was extremely good. My criticism of the food revolves around the packaging. I think we waste too much time fixing it; and, for this particular flight, there was more food than three people could have eaten in 3 weeks. They really gave us a lot of food. I think they probably don't need to provide nearly as much. We had our normal three packages of food, plus this little

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COLLINS
(CONT'D)

pantry arrangement which is very convenient and nice, plus we had a bunch of wet packs. I'd say we probably ate half the food onboard, - We had good appetites and we ate — I'd hate to say how many calories per day, but plenty per day.

ALDRIN

The one disappointing package, I guess, was in the wet packs. The turkey and gravy I thought was outstanding because it was moist. That wasn't the case with the ham and potatoes, nor the beef and potatoes. I thought that both of those were too dry and that the potatoes were not appetizing at all.

COLLINS

In general, I found that the sweet things were not as good as the others. This applied to the drinks as well as desserts. I touched very little in the way of desserts. On the drinks, I felt that something tart, maybe like limeade, would have been a nice addition — or iced tea or something like that.

ARMSTRONG

I agree. In general, I felt the beverages were too sweet.

ALDRIN

I think that we can go still further than we have in the line of the canned spreads going on either bread or toast. I just didn't experience any difficulty at all in zero g

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ALDRIN
(CONT'D)

taking a spoonful of this and spreading it out. As
long as the material that you're using is relatively moist,
it stays together. It doesn't have a tendency to run off
and go all over the cockpit. We had tube spread in the
LM, and I think we could have used that type of a prepara-
tion in the command module, along with more of the
canned variety. Of course, the canned variety presents
a problem of disposal afterwards. It'll certainly have
to be reckoned with. I'm not sure how you make use of a
pill or disinfectant with cans.

ARMSTRONG

The spoon-bowl items were fine; intermediate-moisture
fruits, sandwich spreads, and breads were all used exten-
sively. In general, I liked the pantry approach. I
thought the approach where you went in and selected those
items that you would enjoy for that meal and assembled
your own menu was a very pleasant operating mode. I
enjoyed that, if you could handle your diet satisfactorily
that way.

ALDRIN

I think it would be a good idea to package the pills
along with the spoon-fed packages — either that, or
have some different, more convenient way of dispensing
them. After meals, you gradually dispose of things as

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ALDRIN
(CONT'D)

you're consuming them, and you don't want to have to get up at that point and float down to the pantry to get the pills out to pop one of them in the bag.

COLLINS

I don't know. The business of disposing of all the waste packaging, putting pills in, and all that is very time-consuming and creates a huge volume of waste. Really, the way to do it is to use the pill, then wad everything together, tie the little packet as tightly as you possibly can, and wrap some tape around so that it stays in a small-volume, high-density package; however, this is time-consuming.  It would really be nice if you could have something like a commercial garbage disposal where you could just take all this stuff and cram it in, turn a crank, pull a switch, and have it all sort of ground up and disinfected and spit into a stowage compartment. 

ALDRIN

Either that or some sort of an airlock where you could take this refuse and put it in the airlock and dump it overboard.

COLLINS

Right. But the packaging, getting the food reconstituted, and then doing something with the other packages were the biggest drawbacks. Breakfast would have been improved, I thought, if they had some scrambled eggs, which I know

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COLLINS
(CONT'D)

they have in the lab. I just don't think they have gotten around to putting them on the flight menu, but it would sure be a good idea if they did have some of that. It would be a welcome addition to breakfast.

ALDRIN

In the right-hand seat, I found it convenient to take some of the Velcro that was on the food packs and put it on the scissors. I just found that with the scissors at the end, the cord was just a little bit too unwieldy. That brings up another point. When you put those scissors and things like that in the pockets where you have the dosimeter and a few other things the pocket just doesn't seal right. You move around a little bit and pretty soon you're missing a flashlight, you're missing a pair of scissors, and the dosimeter is off somewhere.

COLLINS

That's exactly right. Now, these inflight coveralls are carefully tailored garments and a lot of engineering has gone into them and they are almost half as good as the summer flying suit. You don't have the problems like that with the summer flying suit because they have zippers in all pockets and you are accustomed to using them.

ALDRIN

Do you care to say a few words about snaps, Neil?

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ARMSTRONG There ought to be a law against snaps. I think that if I were preparing for this activity, for further flight, I would take just a piece of cloth and sew a bunch of little pockets and separators in, and then have a place for all the little odds and ends that you like to keep handy, like your scissors, tooth brush, spoon, pencil, and a bunch of things like that — keep it in one pocket.

ALDRIN One for each individual and a reasonably convenient place for each crew station to mount that sort of thing. There is one now in the LEB and it's a little bit too large.

ARMSTRONG That would have helped keep track of all those little loose items that are just personal necessities. As recorded on previous tapes, we were periodically losing some piece of equipment, a toothbrush would be gone; a camera back, a monocular, or some tape recorder would be drifting around the spacecraft somewhere and it would be a matter of going on a big search to find it.

COLLINS The area behind or above your head in the left-hand couch and the right-hand couch is a convenient area, because it is an uninterrupted bulkhead space very sparsely covered by little patches of Velcro; that was the place where we wanted our cameras, monoculars, and tape recorders. If

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COLLINS
(CONT'D)

there were a couple of spring clips up there, built to be the width of the Hasselblad or if there were more Velcro in that area, it would be a lot more habitable. The doggone camera was always floating around, because there was never enough Velcro really to plaster it up against the wall.

ALDRIN

How about a comment on the coffee?

COLLINS

The coffee was a little disappointing; I don't know what was wrong with that coffee. It wasn't a good brand or the coffee was very tasteless — not tasteless, but it just had a peculiar taste. It didn't taste like coffee. I like instant coffee; I drink it at home all the time.

ALDRIN

It was pretty hot.

COLLINS

The water was hot; now I don't know what it was, but the coffee just wasn't very good.

ARMSTRONG

only a little!
In general, the water wasn't that good. There was a little chlorine taste to it. I found that I drank a lot of cold water instead of the other beverages that were available and I enjoyed it. There was some gas in it. There are some engineering improvements that can be made in the filters, but I think that's possible.

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COLLINS It's well worth carrying those filters. You need them. You might put on the tape that it would be nice to have a fingernail clipper onboard the spacecraft. I don't know where the best place for it is, but it would be very convenient to have in case you rip off your fingernail or get hangnails. At present, there is no tool available that will reach that area.

25.3 WORK-REST CYCLE

ARMSTRONG I guess overall, with a few exceptions that were just discussed, the work-rest cycle on this particular flight was reasonably good. We were essentially operating on Houston time. We were getting our simultaneous sleep periods and essentially it was during the sleep period here in Houston.

ALDRIN All of us elected to have Houston time on our watches and I think it was unfortunate that we didn't have the flight plan also geared to Central Daylight instead of Eastern Daylight. At the top of each page, we had the corresponding time for Eastern. It would have been an improvement, I think, if that had been Central.

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COLLINS Yes, I think they figured that the crew was on Cape time so print local Cape time; but, really, we were on Houston time in our minds. It's a small point.

ALDRIN I'm sure the Control Center would have preferred it the other way, too.

COLLINS Sure.

ALDRIN I had anticipated considerably more difficulty with getting adequate rest, especially the first day. But it didn't turn out that there was much of any problem at all. I thought the sleep stations were very comfortable and the temperatures seemed to me to be very pleasant. I think coming back we noticed that it was getting a little cooler.

ARMSTRONG It was a little warm in the daytime. It was a little cool, particularly at night, on the way back.

COLLINS I think it is important somehow on these lunar flights to get yourself in the frame of mind where you regard the first couple of days of flight as just preliminary to the lunar activities and somehow you talk yourself into relaxing, taking things easy, and getting adequate sleep the first 2 or 3 nights so that you don't arrive at the Moon already tired when the peak activities begin.

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CONFIDENTIALCOLLINS
(CONT'D)

Maybe this is belaboring the obvious, and maybe all crews know this and will think about it, but this is something that we talked about; I think it is kind of a frame-of-mind thing. I think you can talk yourself into either getting all excited and burn up a lot of energy in anticipation or, on the other hand, you can talk yourself into relaxing and taking things easy. Personally, I felt that having flown once before was very helpful to me. I had been up there in zero g before and I wasn't spending all my time pondering the wonder of it all. I was in a familiar place and I was willing to pretend the flight hadn't started until along about the time of LM separation. I think this is important for these flights with extended lunar-stay times, particularly when the crew is flying a flight for the first time. Somehow they ought to talk themselves into a proper frame of mind and get good sleep and arrive at the Moon in a rested condition.

25.4 EXERCISE

ARMSTRONG

We all did a little bit of exercise almost every day. We used either isometrics or calisthenics in place or the Exer-genie. The Exer-genie worked alright. It got a little hot and stored a lot of heat, but it was acceptable.

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COLLINS If you got a good workout on the Exer-genie, it got so hot that you couldn't really touch it. I don't think that is any kind of problem; I just mentioned it.

ARMSTRONG Any other comments on exercise?

COLLINS I had the idea that it was worth exercising on the way home and maybe not worth exercising on the way out.

ALDRIN During the lunar-surface activities, it didn't appear to me that preconditioning in any extensive degree was required. Now, if you were going to take 7 days to get there, it might be a different story. Certainly, with the activities that you have in one g, you are not going to deteriorate that appreciably in 3 days.

COLLINS Well, I felt better in the water when I was first back in one g and stood up in the lower equipment bay. I felt a lot better on this flight than I did on the Gemini flight. I am not sure what to attribute that to. If I had to guess, I would say maybe having the suit on in Gemini and having it off on Apollo — having already stored a lot of heat when I arrived at that point on Gemini and being cool and comfortable on Apollo; maybe it had something to do with exercise or the increased volume inside the spacecraft — I don't know. But I

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COLLINS
(CONT'D)

felt a lot better and I felt in much better shape this flight than I did on the Gemini flight.

ALDRIN

It goes back to what you said before. I think the fact that you have been there and have been exposed to a landing on the water and seas that are not calm as can be — I think having been through it once — the second time does make it a good bit easier.

COLLINS

Maybe that's it. But I can remember a heaviness in the legs on Gemini. I could just visualize those legs being ^{filled?} pooled with blood. It seems like the old heart just wasn't capable of pumping things uphill as it usually was. I felt heavy in the legs, and sort of loggy, and I didn't feel very good. This flight, I didn't notice it at all.

ALDRIN

I think the difference in the space available inside the cockpit enabled you to move in a fairly regular sense and that just wasn't true in Gemini, where you were sitting and didn't get the opportunity to stretch your legs out.

COLLINS

I couldn't stretch all the way out in Gemini. My head hit, or my feet hit first.

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25.5 INFLIGHT ORAL HYGIENE

ARMSTRONG Generally, I can say that we didn't have any problem there. The toothbrushes and toothpaste worked fine. Essentially, we followed the normal pattern just as we would on the ground. As a matter of fact, not in just that area, but in as many areas as we could — eating, sleeping, normal habits, workdays, and so on. We tried to follow a normal pattern as we would on the surface. I think that contributed to the fact that we felt good the whole time, felt rested, and were able to do a good job.

ALDRIN I thought the toothpaste was pleasant.

COLLINS Yes. I brushed my teeth twice a day and everything was normal in that regard.

25.6 EYE-PROTECTIVE DEVICES

ALDRIN In the category of sunglasses, I found that they were of considerable use in Gemini; however, in the command module, I didn't see any use for them at all. Now, they may have been of more use in lunar orbit. In the LM, there were times when we had our helmets on most of the time.

ARMSTRONG I used the sunglasses for a while, early in the flight, and then chose not to use them anymore.

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COLLINS

Yes, I think they are questionable. I would not suggest deleting them. Some people use sunglasses extensively. I know some people, whenever they go outdoors, clamp sunglasses on their eyes and maybe those people would do the same thing in spacecraft. I don't use them very much on the ground. I only use them when driving a car, but other than that, I rarely use them.

I would like to go back to light attenuation under sunglasses. On Gemini, we had a window shade with a Polaroid circular filter in it. I thought it was a little jewel. I tried to get that added one time to Apollo and the CCB turned it down. In retrospect, I certainly couldn't say that that's something that you absolutely have to have, but that would surely be nice for window number 2. I don't know if you all remember; but, during rendezvous, you have to look at something bright. It's great because you have this little circular Polaroid section that you just rotate to any angle you want to get any degree of light you want. It would be a very useful addition, I think, to this storage list. Now, I can't say that it's necessary or mandatory, but in a nice-to-have category. I'd sure swap my sunglasses for that light attenuator any day. The reason is that, when you

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COLLINS
(CONT'D)

put the sunglasses on, you not only attenuate the outside light (which is desirable) but also attenuate the inside light, which is undesirable. With the screen on the window, you can filter as much light as you want and still read all your gages with complete clarity. If you put sunglasses on to block the outside view, it also blocks your inside view. So I guess that's my little speech in favor of that sort of light filter. It would be nice to have. Speaking of window shades, this may not be the best place to bring it up under human factors, but I like to have my sleeping accommodations dark, as dark as I can get them. Certainly the window covers were good, but they weren't as good as they could have been. They were quite difficult to install and I don't know what the reason for that was. We fit-checked them and I don't recall any difficulty fit-checking them on the ground. They were very tight, but not nearly as tight as they were on flight. We got more exercise wrestling with the window shades than we did out of the exerciser, I believe. <Every night, we had a 10-minute yell-and-scream-and-swear session, and jump up and down trying to force the window shades into place.>

Why not an eye mask?

ALDRIN

And they still ended up leaking a certain amount.

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ARMSTRONG It looks like it might be advantageous to have a cinch-down mechanism on those window shades that had a higher mechanical advantage than the ones that are on there now.

ALDRIN Yes.

ARMSTRONG The ones that are on there now require a tremendous amount of force to engage.

COLLINS They require a tremendous amount of force to jockey into position where the lever would fit over the top of them. Then they require an awful lot of additional force to get the lever over center.

ALDRIN It might be interesting to note at this point that, in regard to the spacecraft lighting, I think while we were all asleep was the only time that we really made use of the back lighting and the EL lighting. Maybe this is enough reason for it to have it readily available, so that you don't have to flick on the floodlights, but other than that use, I don't think it's required.

COLLINS The EL light?

ALDRIN Yes.

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ALDRIN Very nice, very pleasant to look at, but we just didn't need it, I thought.

COLLINS Block I used to have floodlighting alone. You'd have to look at a vehicle with floodlighting alone under a lot of different circumstances. If I remember, Block I used to have shadow areas where the struts would get in the way between the light source and the gage and things like that. I'd sure hate to go back to that kind of a lighting scheme. It's nice to have the EL.

25.7 UNUSUAL OR UNEXPECTED VISUAL PHENOMENA

ARMSTRONG Okay, visual phenomena have already been discussed.

25.8 MEDICAL KITS

ARMSTRONG One comment here is that it was pretty clear that the medical kits were not carefully packed. The pill containers blew up as if they had been packed at atmospheric pressure. The entire box was overstuffed and swollen. It was almost impossible to get it out of the medical kit container.

COLLINS I ripped the handle off as a matter of fact, trying to pull it out.

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ARMSTRONG That was even after we cut one side off the medical kit so it would be less bulky so we would be able to put it in the slot. I think that's just evidence of less than the required amount of precaution in packing.

ALDRIN I guess we have never really covered the distasteful area of bowel movements.

COLLINS Why don't you cover that?

ALDRIN Well, from my standpoint, I had anticipated having a bowel movement before the LM activities. And the night before, I spent an hour — 2 hours trying to squeeze out something and it was almost useless. What I accomplished was such a small quantity it certainly wasn't worth the effort. Mike sort of indicated that we probably should discuss this area further and there may be some better way of handling waste material than with the bags. It certainly is messy and it's distasteful for everybody involved to do it in that particular fashion.

25.9 HOUSEKEEPING

ARMSTRONG In general, it's a continual load. There are always things to be done, equipment to be stowed, windows to be cleaned, air filters to be cleaned. There is a continual,

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ARMSTRONG
(CONT'D)

never-ending bunch of chores to be done, which is desirable in some ways, I guess. It keeps you busy on the translunar and transearth coasts. A lot of those areas are required just because of the approach taken toward that particular design, as a lot of the construction in the cockpit — all the stowage equipment — gets put together and assembled in Erector Set fashion. That takes a lot of time and leaves a lot of stuff out. In general, I think it's an area that can still use a lot of improvement.

ALDRIN

I think the idea of having an individual kit where you can place things in individual packages is much better than that large one. And I'd like to see continued effort along this line to come up with better ways of interim stowage.

ARMSTRONG

We used the new stowage that was devised after Apollo 10 and it worked okay. There is probably more equipment available there than you really need, but it worked.

25.10 SHAVING

ARMSTRONG

We did shaving onboard and didn't have a lot of real good luck with that. For some reason or other, we let our whiskers get pretty long before we tried that and found out it was an hour's job to shave.

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ALDRIN

It takes a lot more water than you'd think ahead of time, and getting water on your face is not too easy a task. You can get some to accumulate on your fingers in a thin film and then get it on your face, but invariably it's going to start bubbling and get all over the cockpit in various places.

ARMSTRONG

The only difficulty really was conditioning the beard for shaving. Handling the equipment was no problem and there was no problem with shaving cream getting away from you. It wasn't that kind of a problem.

ALDRIN

Well, it did use up a fair number of tissues to keep wiping it off.

COLLINS

Now, in one g, what you do when you get all through shaving is to bend over the bowl, you take water, wipe it all over your face, and all the bits and pieces of hair go down the sink. But the way we were doing it, when you got through, they were all over your face; then you had to wipe each and every one off. It was sort of hard to get them off. For hours afterwards, they were scratching and itching.

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ALDRIN

I think if I had it to do over again, I would have shaved once before the lunar operations.

ARMSTRONG

Yes, I think it's better to shave more often.

ALDRIN

It was a little bothersome putting that COMM carrier back on again and having a chinstrap going across underneath.

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26.0 MISCELLANEOUS

26.1 MEDICAL REQUIREMENTS

ARMSTRONG We had some and I'm not quite sure why.

COLLINS What do you mean?

ARMSTRONG Well, we had to keep the sensors on and try to get data.

COLLINS I don't see any requirement for that in the command module. I really don't see any requirement for sensors at all. You just have a bunch of extra claptrap, complexity, and power drain, -

ARMSTRONG In general, I think each person should feel like he understands his reaction to various kinds of medications that might be required before flight. I think it's unfortunate when you have to do that kind of stuff in the last week or two before the flight. That should all be done very early in the training cycle so that's no problem or concern to you at that late date.

COLLINS I agree. Another thing is that, it appears to me, we should have pills in two categories — those that we can take without obtaining permission, and those whose use requires inflight permission. And I'd put the motion-sickness pills in the former category. In other words,

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(CONT'D)

the point where the motion sickness is. According to the doctors, at the first onset of any symptoms, you should be taking pills. If that's true, I think you should just go ahead and take one without having to go through the rain dance of calling the ground, getting permission, and then having a big conversation go out to the world about how you are; in fact, are you going to throw up or are not? If the pills are safe, then I think we should be given credit for having the judgment to decide whether to take one or not.

26.2 PAO REQUIREMENTS

ARMSTRONG

I don't guess we had any comment there. We thought our preflight requirements shortly before launch were excessive.

ALDRIN

I think we all feel about the same way about having that press conference conducted here through the glass. It would have been far better to have done that sort of thing earlier. I would think that, that late in the training is too late to be conducting that sort of press activity. I don't think we created a good impression, particularly by the way we went about the protection.

COLLINS

I felt like all three of our press conferences were bombs.
I really did. I guess we have nobody to blame for that

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COLLINS
(CONT'D)

except ourselves. I just felt like they were dull and boring, and that very little useful information was interchanged.

ALDRIN

I agree with that. (I think that the TV inflight should be something that depends on the crew's desires.) I think the more successful ones that we had were ones that were spontaneous, where we just started showing things around. Then the ground, I guess under the supervision of people in our office, can monitor what is received and then ~~release what is appropriate rather than having TV scheduled at certain times and going out live.~~ I prefer not to handle it that way.

26.3 MQF OPERATIONS

ALDRIN

Put wheels on the thing, so you don't have all these problems of people pulling it around from one position on the carrier to another. I guess they're in the process of thinking about this anyway.

ARMSTRONG

We recorded a lot of comments on the MQF design while we were there. Basically, the operation of that piece of equipment was satisfactory with few people at hand.

ALDRIN

We noted that the table was awkward in its location. It was awkward to move around and took up a lot of additional

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ALDRIN
(CONT'D)

space. The windows need to be enlarged if they're going to be used for that type of public-affairs activities. I guess the communications to the outside were relatively good.

26.4 LRL OPERATIONS

COLLINS

I want out.

ARMSTRONG

I guess we don't have any comment there. So far, they've been going as well as you can expect.

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27.0 CONCLUDING COMMENTS

NONE

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