

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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COLLINS
(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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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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COLLINS little. We weren't in it long enough to really feel
(CONT'D) 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 tip-
ped 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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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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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

CONFIDENTIALCOLLINS
(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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ALDRIN
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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
(CON'T)

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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(CON'T)

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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ARMSTRONG
(CONT'D)

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
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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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ALDRIN
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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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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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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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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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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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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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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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