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APOLLO 14 TECHNICAL CREW DEBRIEFING (U)

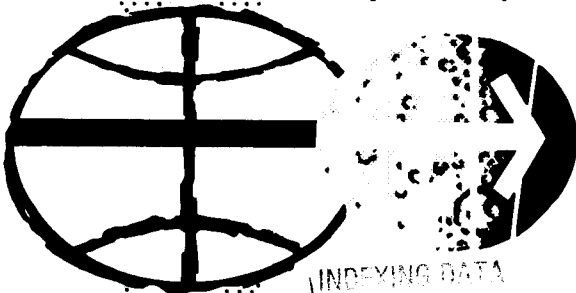
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1.0 SUITING AND INGRESS

SUITING

SHEPARD As far as I'm concerned, the only comment I had on suiting was that it seemed to go very smoothly for me. There were no troubles during the suiting process.

MITCHELL I had no problems whatsoever. The suiting went very smoothly.

ROOSA Nothing at all.

SHEPARD So, everything was apparently functioning all right. Is there a place later on where we talk about sensors? The problems we had with sensors?

SLAYTON In the biomed area.

LIFE SUPPORT EQUIPMENT

SHEPARD I guess that means the PLVs and all that gear. I had no problems with the PLVs, the water wings, the life rafts. The life vests all fit all right. The PGA connections and suit circuit check, as far as I was concerned, went perfectly and right up until ingress. I experienced no problems at all.

MITCHELL I have no comments at all to make except that it went very smoothly.

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SHEPARD I might say that so far as the ingress was concerned, I thought that the support team did an excellent job. The Suit Technician and also Bruce McCandless inside the spacecraft. All of them did extremely well. There were no hitches or anything of any kind that I could see. The straps - the connections - were all made properly, and the TCP seemed to be in great shape. I don't think we have any negative comments in that section, do we?

ROOSA No.

MITCHELL I don't.

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[REDACTED]

2.0 STATUS CHECKS AND COUNTDOWN

SHEPARD Was there any problem with ground communications during countdown?

MITCHELL The only thing I recall was a slight change in format from CDDT and the mission sim in the way that we checked with Houston, which was somewhat of a surprise. I don't recall the details of exactly the way it changed. It was fairly inconsequential, but it was a change.

ROOSA Until launch day, they always went to LMP and then CDR and then CMP; on launch day, I think they started out with CMP first. They changed that order in there. There was a difference in the wording on that S-band/UHF check. It was of no consequence.

SHEPARD Well, that would have been out of the MOCR count. That wasn't anything to do with the other stuff.

MITCHELL Yes, that's right.

SHEPARD Launch preparation.

ROOSA You just mean the actual countdown?

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MITCHELL Well, I have one comment there. Just before the EDS checks, we had a callout from the TCP to use the full name of the SECS logic breakers. They were confusing to me. As a result of the terminology, which was unfamiliar to me, instead of putting those two in, I checked the EDS BAT A and BAT B breakers. The only suggestion I have is to recognize the fact - I think it's probably true of all the switches in the spacecraft during the countdown - that they are going to use the switch names exactly as printed on the console and not the familiar names we use in the CMS with the instructors there. That was confusing to me at one point and caused a slight hitch as far as the EDS checks with the vehicle are concerned. That's the only thing I can think of that was out of phase as far as the countdown sequence was concerned.

ROOSA I don't remember anything else. Everything seemed to go well. The azimuth change went well. The suit loop was nice and comfortable. It was hotter than during CDDT. The temperature during CDDT seemed to be 5 or 10 degrees less on the gage than we had during launch.

MITCHELL I felt a little bit too warm during the countdown. I thought it was very comfortable during CDDT.

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[REDACTED]

ROOSA Yes, I think that the suit was definitely warmer; not only from the physical standpoint of feeling it, but on the gage.

MITCHELL Yes, it was.

ROOSA It was warmer. As far as I was concerned, it was better; I froze during CDDT. I don't have any comments on the hold. We just sat there and waited.

MITCHELL I think I slept through most of it.

SHEPARD I'd just like to make one comment as far as the condition of the crew station was concerned. The PREP was excellent. Just looking around, I didn't find any discrepancies at all in switch positions or red tags left in the vehicle. Remembering the general condition of the spacecraft, I think it was excellent. Did you all notice any problems?

MITCHELL Nothing. Absolutely immaculate.

ROOSA Not a thing. One thing they did do that I thought was good and, hopefully, they are squared away now, but during CDDT, we ended up with the hatch window reasonably - well, I hate to use the word "dirty" - but it had quite a few particles of stuff on it. After that, I know they commented to the closeout

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ROOSA (CONT'D) crew about it. During launch, just before they put on the BPC, they cleaned the hatch window and it ended up in good shape.

SHEPARD Distinction of sounds in the launch vehicles - sequence of countdown to lift-off; nothing surprising here as far as I was concerned.

ROOSA I think it was less than what I expected. I thought, as we approached the ignition sequence, that we'd hear more of the valves and stuff opening up down there. I didn't hear anything unusual at all.

MITCHELL Just little jiggles.

ROOSA Yes.

SHEPARD Yes, and again to reiterate on the hold which occurred, we had practiced that someway. We had practiced that during CDDT.

ROOSA What? The launch azimuth change?

SHEPARD Yes.

ROOSA Yes, we did; no, it was in the FRT.

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[REDACTED]

SHEPARD FRT, that's right. That had been practiced once before in the vehicle, and I recommend that you do it again in future countdowns.

ROOSA I think so. It's very simple and right out of the checklist. I think it's a good one to go through in FRT; not for the CMP's sake so much as for the entire system, for the test conductor, and everybody to just to run through it.

SHEPARD Including the Flight Director.

ROOSA Yes, I think it's a good exercise.

SHEPARD That was the only thing as far as the hold was concerned. Of course, we couldn't see what the weather was, and we were trying to second-guess everybody. But, the hold itself wasn't bothersome.

ROOSA No. I didn't notice the rain. Evidently it had rained and was raining during the hold or just before it. I really didn't notice it at all on the window.

MITCHELL That's right. We never did get any moisture at all on the window that I could see.

ROOSA I didn't notice any moisture on the BPC, on the vent. You know, on Apollo 12, they had trouble with it underneath the

[REDACTED]

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ROOSA (CONT'D) BPC. They had ice; I don't remember any on the windows. So, I guess any comment on the moisture is all on the positive side.

SHEPARD Ed, do you have anything more on section 2?

MITCHELL I don't have a thing, Al. You might comment that, as a result of previous briefings on sounds and sequence of events that happened in the training, it seemed very natural to go through this time. There were no surprises.

SHEPARD Well, we've been running over the hold again. I guess that the consensus is, concerning the information passed between the STC and the LOM, there was never any question in our minds as to what the hold was for and where we stood in the count. We never felt we were not being informed or were behind the power curve at all, in that respect.

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3.0 POWERED FLIGHT

SHEPARD I didn't notice too much that was unexpected in the launch phase. Of course, most of my attention was on the forward panel. Maybe Ed had more of a chance to look out the window and sense vibrations.

S-IC IGNITION

MITCHELL On the S-IC ignition, I don't recall hearing anything until shortly before lift-off. I felt the vibrations start to increase and the stack start to shake. The noise started just before lift-off.

LIFT-OFF

MITCHELL At lift-off, the vibration of the spacecraft reminded me more of a trolley going down a rough track, or an aircraft carrier catapult launch. But, I was expecting that. In fact, we had been briefed on it, and it was no particular surprise. I think people should be aware of what it will feel like, and that the sounds are not particularly significant. I had no trouble hearing what Al and Stu were saying or hearing the communications.

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LAUNCH VEHICLE LIGHTS

SHEPARD The engine lights were exactly as scheduled. The roll program was exactly as expected with the new azimuth. The pitch program was exactly as expected.

PITCH AND ROLL PROGRAMS

SHEPARD The DCPS and the CMS provided enough variance in rates for nominal profile so that the vehicle rates, that we saw during the launch, were not unexpected at all. As a matter of fact, it was reassuring to see them.

CABIN PRESSURE EFFECTS

MITCHELL I noticed the cabin pressure starting to drop at about the 50-second mark where it's supposed to. The noise from the cabin pressure decreasing did not come until a little while later, and I didn't quite understand that. The cabin-pressure needle was dropping before I heard the sound. The sound, as simulated in the CMS, is precise. It's a high-fidelity simulation. The CM simulation of cabin pressure decrease was very good.

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ENGINE GIMBALING AND RETRO MOTION

MITCHELL I felt no engine gimbaling. The noise did build up as we approached max q, but not as much as I expected. I think in the CMS, we probably are used to having the sound turned up a little bit too high. I did not notice nearly as much sound as we're used to listening to. After max q, it became very quiet and very smooth, and all of the vibrations associated with the dynamic range disappeared. From there on, it was a very smooth ride. I do not recall feeling any engine gimbaling or retro motion whatsoever.

S-IC (INBOARD AND OUTBOARD) ECO

MITCHELL I was able to feel a slight decrease in thrust and a slight decrease in g-load from the inboard engine cut-off, but it was of no particular consequence. When the outboards cut off, as we had previously been briefed and as previous crews had discussed, there was a sharp unloading. I expected to be thrown against the instrument panel, and I had my hands out to brace against it. But it was not as much as I expected. I do recall feeling the unloading reverberate through the spacecraft in several pulses. I don't recall the frequency of reverberation, but it felt like it went through the ship, was reflected, came back through, and back through again. Or perhaps, they were

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MITCHELL distinct pulses. In any event, there were several pulses
(CONT'D) associated with the inboard cut off.

SHEPARD Yes. Two or 3 cps, somewhere along in there.

MITCHELL Somewhere in there. Yes.

SHEPARD Is that what you thought?

ROOSA Yes. I think so.

SHEPARD Or maybe eight or 10 pulses.

ROOSA Yes. I'd say the S-IC shutdown was a lot less dramatic than
I expected.

MITCHELL Yes. Definitely for me too.

S-II IGNITION

MITCHELL I don't recall anything significant about it. In my opinion,
it was smooth. That was a very smooth ride after the ignition.

PROPULSION MIXTURE-RATIO SHIFT

MITCHELL Stu called it, and we heard it and felt it. The shift was not
as dramatic as we had expected.

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[REDACTED]

ROOSA I thought it was just the opposite. I knew it was coming. I felt it more than I expected to. It just felt like you cut in the AB (afterburner) on the stack.

MITCHELL Maybe I was expecting something similar to the bang you've been making in the spacecraft and it was disappointing from that point of view.

ROOSA Yes. Maybe that was it. I had been simulating that with a little vocal noise at mixture-ratio shift, but the change in thrust was very evident. It was like cutting in a smooth afterburner.

LET AND BPC JETTISON

MITCHELL While the BPC was still on, I was unable to observe any effects of the staging. Maybe one of you should make some comments about the visual effects of separation.

ROOSA You could see when the retro motors fired. You could see them. When we had staging, when the retros fired, we got the flash coming forward. I could see it very distinctly. I also saw ice. I thought maybe it was part of the separation garbage.

MITCHELL When the escape tower and the BPC jettisoned, there was quite a bit of noise and flash associated with it, and quite a bit

[REDACTED]

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MITCHELL of debris that came off. It was louder and more dramatic than
(CONT'D)

I expected, but of no particular consequence.

SHEPARD There wasn't any question about the fact that it went.

ROOSA It's like all the pyro functions.

MITCHELL All the pyros - that's right.

ROOSA You know they happen.

S-II ECO

MITCHELL I thought the S-II cut-off was more dramatic than the S-IC.
Maybe that's because I had been thinking about the S-IC being
the dramatic one and not thinking about the S-II. In any
event, it appeared to me that I noticed the cut-off of the
S-II more. I don't recall there being the unloading and the
pulsing associated with the S-II that we had with the S-IC.
Maybe you'd like to make a comment on that. I just don't
remember it.

ROOSA I don't remember any pulsing, but you definitely know when it
shut down. I went forward on the straps.

MITCHELL That's right.

ROOSA And more so than what I expected.

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S-II/S-IVB SEPARATION

MITCHELL There was a great deal of debris, ice, and pyro-function noise associated with it. It was a very loud and "messy," separation in the sense that there was quite a bit of debris thrown around.

SHEPARD I think that pretty well covers it. As far as the launch phase is concerned and the vehicle functions. I don't think there's anything other than what Ed has discussed, the pogo we get into later. So, as far as the vehicle functions are concerned, I didn't notice anything out of the ordinary. As a matter of fact, I think we've already said that there really was nothing that we had not expected. Everything was just about as we had been briefed or noticed in the trainers.

COMMUNICATIONS

SHEPARD I had no problem with communications at all. I had both the volume controls turned up full. I did not have any molded earplugs inside the comm carrier, just the regular circular earplugs. I had no problems with communications from the moment of ignition, right on through. Any comments?

MITCHELL None whatsoever. And I wasn't wearing plugs either.

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ROOSA I don't think anybody wore the plugs. In fact, I was kind of surprised at the communications before Bruce left the spacecraft. He turned my audio center full up. During the comm checks with Houston, they didn't sound that loud. I really expected them to come booming through with the volume all the way up. They didn't. They came through at a comfortable level. During the launch, they came through at the same level. Even with the outside noise, it appeared to be just about the same, prelaunch and during the noisy part of the boost up before max q. But it was good solid comm all the way.

CONTROLS AND DISPLAYS

SHEPARD As far as controls and displays are concerned, we've already commented about the launch vehicles lights (sep light). Everything worked just as we expected. As far as the rest of the controls are concerned, such as the attitudes and rates, here again, we looked at a number of different type of off-nominal runs on the DCPS and on the CMS. Everything on both those vehicles is pretty well programed. Of course, we had no engines out. We had no guidance failures. So, I can't comment on that area. But, as far as the nominal displays of rates and tank pressures were concerned, they were just about as expected. The guidance came in and looked just like it was

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[REDACTED]

SHEPARD
(CONT'D)

supposed to. We had the change in the S-II attitudes with center-engine cutoff just like we had expected. All of these, we were able to monitor very well on those displays. And, of course, Stu was using the DSKY displays to back up a launch profile. We'll let him comment on those, but from the standpoint of the attitude rate and tank pressure displays, all were just about as expected. Here again, I think, that the fidelity of the DCPS and the CMS is such that making off-nominal runs and sims, and so on, you're well prepared for what you'd see on the spacecraft.

MITCHELL I have one comment on the display: the fuel cells were configured with cells 1 and 2 on bus A and fuel cell 3 on bus B. In the CMS, it's simulated in such a way that all three fuel cells are putting out about the same amount of current. In the vehicle, I noticed that fuel cell 3 was more heavily loaded by about 4 or 5 amps than 1 and 2. Because this had been questioned in the CMS, I was somewhat surprised. And I suggest that it be looked into.

ROOSA Joe Sunder knows about that. He told me to look for it and that it would be there. I think they're going to have a patch or something put in that. It worked just like he said it was going to.

[REDACTED]

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SHEPARD Let me just say one more thing about the lighting for those controls and displays. We had all the cockpit lights turned up; therefore, our light levels and visibility of controls and displays were just about the same as those in the CMS. So, the fidelity there is also good. We had no Sun factor to contend with during launch. How about the DSKY?

ROOSA I had no trouble with the DSKY. I had no trouble following the profile on it. In fact, during most of the launch phase, I kept thinking I was forgetting something, that things were going so smoothly.

MITCHELL One more comment here because it's applicable here and throughout the rest of the flight. When we brought the gimbal motors on, as we had previously been briefed, the ammeters showed the presence of the gimbal motor transients far more distinctly than did the hydrogen and oxygen supply in the fuel cells. And it was also interesting to note that the number 2 gimbal motors caused a larger transient than did the number 1 gimbal motors by probably 4 or 5 amps. The number 2 gimbal motors were very sharp and with a large transient. The number 1 was sharp but with about a 5-amp-less transient.

ROOSA Number 1 fuel cell on 2's. On one fuel cell on the 2's.

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MITCHELL Yes. And that is the explanation for it.

CREW COMFORT THROUGH POWERED FLIGHT

SHEPARD Okay. Then, during our launch phase, was everybody comfortable? Did anybody have any problems?

MITCHELL None at all.

ROOSA No problems at all, and in reference to throwing the switches, going up the line, and working the DSKY, it was no problem at any time to do that under the g-load at all. Al and I didn't have any interference with our suited gloves as far as reaching over the hand controller. All of the switch throwing and the freezing of the DSKY to check the profile went extremely well. In fact, the g-load felt pretty light. I guess, it got to 4 g's, but it was certainly no problem at all to the CMP as far as moving his hands and working in the center seat.

SHEPARD Yes. I think that's generally true. We didn't have too much interference because we've made quite a few suited launch runs. Not only in net sims but also on our own. So, I think we worked out the details of working together over there in the busy corner.

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ROOSA Yes. I don't think we had any interference and had no trouble at all reaching any of the switches that we would have had to get to.

SHEPARD So, we had no comfort problems.

COMMENTS ON POGO

ROOSA We covered that in the debriefing on the loop, but on the S-II stage, we started picking up a slight pogo, and, when I say slight, I mean that. But it was of an amplitude large enough to be definitely felt. When I felt it, I noticed the time was at 8:40 into the launch. It seemed to steady out at a rather low amplitude and remain relatively constant right on up through to the S-II burn. Really, it was of no particular concern. I'm sure if somebody checks the voice tapes, it's on there because we talked about it during the launch and I called out the time on the tape. It didn't appear to be increasing nor decreasing. It was rather a constant level pogo of some low magnitude. It wasn't disturbing, but it was noticeable.

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[REDACTED]

4.0 EARTH ORBIT AND SYSTEMS CHECKOUT

EVALUATION OF INSERTION PARAMETERS

SHEPARD All right, there's your launch checklist. You want to read out the parameters?

ROOSA We shut off with the DSKY showing 102.9 by 99.1. Then I think it came back up. We were very close to 103 circular on the orbit. So we saw that in simulations, too - the CMC being a little off. It started on time. It wasn't a manual start, but I think that's just within the scatter of the CMC and the IU computation. On going into Earth orbit, it looked like we were pretty much on profile. We had no worries, no problems; and we showed a velocity of 25567. It shut down right on time, and everything looked real good to us on board at the time.

MITCHELL We were standing there, and I was saying, "Okay, one more COMP cycle and it will shut down", and pow! The light came on just as advertised.

POSTINSERTION SYSTEMS CONFIGURATION AND CHECKS

SHEPARD We had gone through this a number of times suited in the CMS at the Cape, and I think we felt before launch that we had

[REDACTED]

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(CONT'D)

that area pretty well nailed down. We wanted to be sure that we were able to do it, and I think my feeling's still the same. I think we had no problems at all. In our postinsertion checklist, we were benefitting from other crews' past experience in getting that thing pretty well practiced; so we knew where everything was. By the way, I think that when you call out that stowage configuration down there at the Cape now, the CMS is in excellent shape for that. You do specifically have to call it out because they don't always do it for you. When it has been established that's the kind of stowage configuration you want, all the equipment is there and we were able to practice everything with it, including the cameras and all the cockpit equipment. I think it went well. Does anybody have any comments about that?

ROOSA

No. I think it went extremely well. I think the CMP here is out of the couch and is going about retrieving the various items. As Al said, we had practiced that enough so that it was really no problem. I got it all done and watched the sunrises and sunsets and looked out the window a good bit of the time. It was really a no-sweat operation. We were way ahead of the time line all the way through those insertion checklists.

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[REDACTED]

MITCHELL I guess we ought to read into the record here that you recorded parameters that were recorded at that point. On the SM RCS, we had helium pressures after insertion. These are parts A, B, C, and D in order: 4190, 4000, 4100, 4100. Helium tank temperatures, again in order: 75, 74, 81, and 77; and the propellant quantities were all reading 100 percent. I might add that I invariably have had a bit of trouble getting through the checklist in the time that is marked here. Now I recognize that this is not an in-order sort of checklist. Nevertheless, getting the tape meter turned on, the VHF A off, and the simplex and VHF B off, I was 3 minutes and 26 seconds late simply because LOS slipped up on me; and I didn't realize we were at LOS. I arrived on that page of checklist, and it was already LOS; so my suggestion is that we ought to move that 23 minutes, or these time frames, up a little bit so that you see them earlier as you are scanning the pages. I was methodically going down through the different checklist items; even though I had tried to cue myself to remember LOS, I had to jump half a page over to catch that item. Nevertheless, I was still a page or so away, and it just slipped my mind for a couple of minutes; so they probably lost about 3 minutes of data after LOS because of that.

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ORDEAL

SHEPARD All right, no problem with the installation of the ORDEAL. It came out just as advertised. We got up there - no problem.

COAS AND HORIZON CHECK

SHEPARD The COAS came off, and the mounting was installed as advertised - no problem with those two items. Stu, how about the optics covers?

MITCHELL Here are some more parameters we ought to read for the record for the EPS system. The H₂ quantities were reading 95, 95. Onboard O₂ was reading 100 percent, 100 percent, 61 percent. The main buses were reading 29.2 and 29.0; the BAT buses were reading 32, 32, 37; and the pyro bats were reading 37-1/2 and 37-1/2. The SPS monitoring check: oxidizer, 100.6; fuel, 100.4; with an unbalance of plus 50 pounds.

OPTICS COVER JETTISON (DEBRIS)

ROOSA I adjusted the optics covers on the pad. I think it was during one of the tests. It wasn't FRT but, anyway, it went just about like that. I guess that the light transmission through the telescope was less than I had expected. I wasn't dark-adapted, and it is hard to verify immediately that the cover is off the telescope. It takes you a little bit to

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ROOSA
(CONT'D)

adapt and to make sure that you are seeing the stars. I noticed "Debris" listed here. I saw no debris at all associated with the optics cover jettison. You could hear them. I did hear them and was watching the shaft angle and everything went fine on that.

UNSTOWAGE

ROOSA

The unstowage went just as the checklist. It was no problem at all to - under the zero g, of course, it goes a lot easier than it does in the CMS, particularly when you are suited. I had no trouble getting by the Hycon box and underneath the left-hand couch to get out the stowage bags. Then the unstowage went extremely well, and I had a lot of time.

SHEPARD

I'd just like to say that Dell'Osso did an excellent job with all of our stowage items. I really felt secure in the knowledge that he was there dealing with them. It was a couple of weeks before launch, I guess. I really felt that we had everything in good shape as far as the stowage in the command module was concerned.

ROOSA

Ray did an outstanding job on everything, and he's really a giant among the support team as far as I'm concerned. In the stowage of the CMS, a lot of the credit has to go to Ray, also, because he got the items and came down and verified that they

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(CONT'D)

were exactly like the spacecraft. He really had us well prepared all the way through on the stowage items.

SPEAKER

Do you think he did an outstanding job?

ROOSA

Absolutely. Man, there's no way you can give Dell'Osso too much credit. He did a thoroughly good job. I worked with Ray a lot, and everything that Ray puts his hands on is done in a superlative fashion.

COMMUNICATIONS

SHEPARD

All right, any negative comments on comm?

ROOSA

You know we had our volume up full for launch, and after we got in orbit, this degraded the VHF comm until we got our volumes turned back down. We were overdriving the VHF on our audio center, and once we got the volume turned back down to a normal level, the VHF was certainly a lot better.

SHEPARD

Yes, that's a good comment. The VHF was starting to go fuzzy there until we got the volume down.

MITCHELL

Comm, in my opinion, was beautiful. Because I had the instant control at my thumbwheels, I didn't have anything else to worry about as far as comm was concerned. I could play it in real time to get the best comm. I had no problems whatsoever.

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TLI PREPARATION

SHEPARD All right, TLI prep. We got the updates all right, didn't we?

MITCHELL Oh yes, we had plenty of time on that. I don't believe we read out the numbers to anybody on the SCS attitude reference check. For the record, we should read the SCS attitude check. For the DSKY, the numbers were 180.09, plus 128.00, and 000.22; for the ascent values, we had 180.9, 128.8, 359.8, and that was to null the FDAI-1 error needles.

SHEPARD Since we're going to talk about it later, we probably ought to comment here about the extension of the docking probe. Stu did that, and we noticed no anomalies.

ROOSA The thing went exactly as advertised. We got a flash of the barber pole. They went gray and we got the audial cue and felt the vibration as the probe extended. There's no doubt but what the probe was extended in the proper manner. Everything went just as it should have, and we did feel the probe go out.

ROOSA I never have understood why we do a null bias check on a venting booster here, but it's in the checklist, and we did it.

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SHEPARD Was that minus 12.9 that we wrote down there?

ROOSA Yes. It seemed like it was.

SHEPARD Because it got up around 21 later.

ROOSA Yes. That's the DELTA-V test. The DELTA-V test is good to do here but why we do a null bias when we are under acceleration of the S-IVB I don't know. Maybe they feel it's so slight that it wouldn't show up, but it did kick the null bias around a little bit. I don't know if we wrote down that value or not.

MITCHELL I'd like to make one comment on the checklist here. In the sims, it seemed like the time between insertion and TLI was forever and a day, there was more than ample time to do everything. In flight, there was ample time to do everything; however, that time passed very rapidly. We completed most of the insertion work well before reaching the West Coast. We had started the TLI prep over the East Coast. There was not a great excess of time to do anything else. I wouldn't advise other crews to add a lot of other things into the time line at that point. There was no excess time. It was a comfortable time.

MITCHELL Incidentally, there's one blank here that, I guess, would come under TLI burn: the GET of the TLI burn that was

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[REDACTED]

MITCHELL recorded. If you're going to start talking about that,
(CONT'D) GET was 02:28:41 by the onboard clock.

SUBJECTIVE REACTIONS TO WEIGHTLESSNESS

SHEPARD We prepared ourselves as I guess several other crews have in
the past. We went out and flew the T38s for the last time on
Friday.

ROOSA I flew on Saturday morning.

SHEPARD Friday for me, Saturday morning for you.

MITCHELL I flew Friday.

SHEPARD So, within 1 or 2 days of the flight, we conducted high-
performance aerobatics, rolling, upside down and right side
up, and dog fighting in our T-38s. As a result of that and
moving about fairly slowly at the outset, I found that I had
no problems at all in any of these areas of vertigo, nausea,
or any vestibular disturbances whatsoever. I did feel a little
full in the head, full sinus feeling, but I guess this has to
do with the readjustment of the cardiovascular system and
nothing to do with any of the other sensory perceptors. So,
I really had no problems adapting to weightlessness.

SHEPARD Ed, do you want to comment on that?

[REDACTED]

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MITCHELL I have nothing to add to what you have said, Al. I might add that I went out and flew aerobatics a week or so in advance of the flight. I did have some sensations because it had been a long time since I'd done aerobatics and I did get a little bit of vertigo and a little bit of queasiness, but I flew again and was all right. So, I went out and flew the Friday before the flight. I was all right. I had absolutely no sensations whatsoever in zero g except, as Al said, a little fullness in the head which persisted throughout most of the flight.

SHEPARD Stu, did you have any problems?

ROOSA No. I really gave myself a workout in the airplane because I knew I'd be the first one to be moving around, so I really worked that airplane over before the flight. I had no nausea or anything like that. I did have a feeling right at orbit insertion as the g came off; for a few minutes, I felt as if I were standing on my head. In fact, I think I commented on this on the tape. I said, "Hey this seems strange. It seems like I'm standing on my head." But then that went away, and then I got to moving around and everything was fine. If you're looking for every little thing out of the ordinary here, and I'm not sure whether that was due to the fullness in my head or what it was, but it just felt like, there for

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[REDACTED]

ROOSA a while, you were standing on your head for a few minutes.
(CONT'D) But there was certainly no disorientation or anything like
that connected with it.

SHEPARD I would say that, generally, the concensus is a negative
reaction in that area.

ANOMALIES

MITCHELL Because we had no anomalies, there was some pad. If you had
a small problem, it would eat that time up in a hurry.

SHEPARD That launch checklist should be in good shape. If the crews
practice it, they shouldn't have any problems.

[REDACTED]



5.0 TLI THROUGH S-IVB CLOSEOUT

TLI BURN

MITCHELL The GET for the TLI burn was 02:28:41 by the onboard clock.

SHEPARD We've already mentioned that, as far as the update, the pads for the TLI came through in plenty of time. We didn't have any problems in getting our cue cards, getting updated, or anything else. The pad is right in the launch checklist, so it's available. We didn't feel rushed there. It was an off-nominal pad as a result of the delayed lift-off. I didn't have any sense of being behind the power curve on that one at all.

ROOSA They changed your ORDEAL angles by 2-1/2 degrees.

SHEPARD Correct. That is what we practiced before and that wasn't any strain. We've already debriefed on the ORDEAL angles. We debriefed on that during the inflight debriefing. So we will not discuss those anymore.

I thought the burn went very smoothly. From my point of view, everything looked just as advertised. The guidance looked good, and the inertial angles and the ORDEAL angles looked just as we had expected them to be. We noticed nothing unusual at all. I thought the burn went great. Stu was monitoring

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SHEPARD (CONT'D) it, as we always do, on the DSKY and was ready to shut it down if the occasion arose. It shut down just about nominal.

ROOSA That's right. The difference between what I read and the pad value was 17 feet. And you let this go a comp cycle and then freeze it. The inertial angles to the burn were absolutely on the money. The altitude was running 2 or 3 miles low on every check. The inertial angles were absolutely right, the velocities were real good, and the shutdown conditions were good. Throughout the burn, we were riding a little low on the altitude. ΔV_C was a minus 8.8 at the end of the burn.

SHEPARD They had uplinked us before that update. So the CMC should have been good.

S-IVB POGO

SHEPARD So right up to cut-off on the S-IVB, we had no surprises. It was smooth and as steady as can be. We had no notice of any pogo. I commented about a little buzz toward the latter part of the burn, but nobody else seemed to notice it. It was pretty obscure if it was there at all.

ROOSA It was there, but it was not pogo.

SHEPARD Yes.

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[REDACTED]

MITCHELL No, it's not pogo, just a buzz.

ROOSA Yes. I think we told them about that during real time.

SHEPARD There was nothing unusual about the S-IVB maneuvers.

ROOSA It was just as advertised.

SEPARATION FROM SLA

SHEPARD We went right down the checklist for separation.

ROOSA Yes.

ROOSA The pre-SEP checklist went well. It looked like the booster was holding the degree and a half dead band, and it went to the right attitudes.

SHEPARD The venting was fine at the cut-off. There were no tank pressure problems; everything vented right on down.

ROOSA Once the tanks start venting, they looked good. You and I switched seats at that point.

DOCKING

ROOSA After we swapped seats, we went on to the checklist and the transposition and docking cue card which is a very good cue card. It goes right down the checklist. We went right by

[REDACTED]

CONFIDENTIALROOSA
(CONT'D)

the numbers. We made sure we were going right down the checklist. We came up to SEP. Like all the other pyro functions during the flight, it's the one thing you can't simulate. It is a very definite thing. There is no doubt in your mind that a function has occurred whenever you hit a switch. We brought the translation ullage on at 58 on the clock. At zero zero, we were definitely off of it. The pitcharound went extremely well. Al and I coordinated on that one real well. VERB 62 needles were indicating a pitchunder so I went to ACCEL COMMAND per the checklist and pitched her up. The pitch needle went up, Al did his thing on the DSKY, and we were on our way. At the end of the pitchup maneuver, we came back around. It was like the CMS. Sometimes you end up with the COAS boresighted on the docking target and sometimes you end up just a little bit off. In this case, we were off slightly. The roll looked real good, and the COAS lined up just a little to the left of the docking target. The procedures on the way back in went well. It looked like we were headed for a nice smooth docking when, to our surprise, it didn't turn out that way. We eased up on the booster. Al could look out through the hatch window, which I hadn't realized, and get a good view of the LM as we're coming in on it. I'd say the first approach was right at 0.2 ft/sec, and the alignment was real good. We came in

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ROOSA
(CONT'D)

[REDACTED]

and Ed called "contact." Then we fell out of the drogue. My immediate reaction was to give it plus-X and shove it back into the drogue. It didn't take. My concern was not to waste any more RCS gas than I had to, so I gave it a 1- to 2-second burst of plus-X to drive the probe back into the drogue. We had contact again and sat there for a second. I eased up on the THC and we backed out of the drogue again. I came off and decided to try it again and increase the closing velocity. This time I'd say we hit right at 1-ft/sec closing velocity. I did not give it any ullage after contact on this one. I wanted to see if the faster closing velocity would catch us. We hit almost dead center on the drogue, and we didn't capture. As I came off the drogue this time, I noticed scratches on the drogue. I don't think they were there after the first one, but I couldn't verify that. I did see them at this point. We stopped and looked at them and called Houston about them. Later, when Al and Ed were in the LM, I went into the LM and drew the scratches to scale. I didn't have a ruler to measure them. I have a drawing of the scratches on the drogue. This made me think that the capture latches were locked and that we were getting these scratches on the drogue but they weren't going all the way down to the hole. Later, close examination showed that we had three deep scratches 120° apart, just like the

[REDACTED]

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(CONT'D)

capture latches, only they weren't extending all the way into the hole. When I saw this, it appeared to me that the only way for this to happen was if the capture latches were locked instead of in the cocked position. We backed off, flew formation, and talked with Houston. Houston recommended that we do another docking and this time give it a sharp plus-X for 3 seconds after contact. I came in again at what appeared to be a normal docking. I'd say we were closing around 0.3 ft/sec on contact. We didn't capture. I held plus-X for a solid 4 seconds this time just to be sure. We didn't capture again. We came back off the drogue. It seemed like a considerable amount of time between this attempt and the next one, while Houston massaged the problem. We were formulating some plans of our own during this time. After telling Houston what it looked like, they suggested one more normal docking with a plus-X. We tried and that didn't work. Then they said to try another docking, hold plus-X, and RETRACT. We moved in, got in the drogue, and steadied up. This was very steady. When I applied plus-X, it would hold just as steady as a rock. There were no oscillations when I applied plus-X thrust.

MITCHELL There might have been a first initial slide into the hold, but it was always just a bang and a pop back out. There was never any wobbling.

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SPEAKER You just had impact and then a rebound.

ROOSA I was convinced I was hitting it in the hole. I don't know why she didn't latch. I don't know if anybody knows yet or not. We talked this over and decided Al wouldn't retract until I had the plus-X on it and was satisfied with the alinement. Everything looked good. I held plus-X, and Al hit the RETRACT. I was concentrating so hard on making sure the alinement was good that I didn't see the two vehicles come together. I think the data show that the capture latches actually moved before the bottle fired. I was holding a plus-X, everything was steady, Al hit the RETRACT switch and then said "It's not working." There was a considerable period of time between the time he hit the RETRACT switch and something happened. I can't say whether the vehicles were coming together during that period of time because I was really concentrating on the alinement. It was our understanding that we were going to retract the probe and catch along the docking ring. I wanted to make sure that I didn't let the alinement get off.

SHEPARD The latches stayed gray long enough for me to make that comment. I realized that they didn't go barber pole; then, within a fraction of a second, they went barber pole and shortly after that gray and then we had the ripple-fire hard dock. It was

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(CONT'D)

obvious that we had a good hard dock. That was 4 seconds from the time the switch was thrown.

ROOSA

From the data, the capture latch motor was working. I thought somehow during that retract cycle the capture latches went from the lock to the unlock position and that allowed it to slide into the drogue. From looking at the scratches, I was under the impression that the latches were locked when we were trying to dock. I don't even know if this is possible. I don't know what they've come up with.

MITCHELL

I don't know either, but from being an observer watching them work at it and observing out the window what was going on, my impression, independent of theirs, was exactly what they have said. We came in, hit, and nothing happened. Stu applied plux-X thrust, and Al hit the switch and apparently the probes turned to retract. They called barber pole and, an instant later, the ripple fire of the hard dock latches.

ROOSA

We did get the hard dock and we were on our way. During the time that we were talking with Houston, I spent quite a bit of time stationkeeping with the S-IVB. I tried to use as little RCS gas as I could because I knew I had hosed away a lot. I saw venting in the S-IVB while we were in front of it and that was a beautiful sight. It was something to behold. We had the

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ROOSA
(CONT'D)

TV on; I don't know how it came through on the TV but it sure was beautiful. I had the S-IVB and the LM out my front window and the Earth out my left-hand window and, by the time we got docked, we were really hauling the mail. The Earth had shrunk into a sphere. It was a beautiful sight. The station-keeping was absolutely no problem and the S-IVB attitude hold was magnificent. Through all the venting, it held steady as a rock. The only movement we had was within the dead band of the vehicles. Once we had the hard dock, we went right into the tunnel work.

SHEPARD Yes, we had the light burned odor like everybody else has as soon as the hatch came out. We went right on with the checklist. The hatch removal was right on schedule and the ECS functions likewise.

ROOSA I don't know if we wrote that down.

SHEPARD Two out of 12 handles had sprung back from the closed position. But as far as the bungees were concerned, they were parallel all the way around. We had definitely made a hard dock on all 12 latches. I think we all agree that it was kind of a ripple-fire motion. It wasn't 12 at one time. After our hatch removal everything went fine. We got the umbilicals in and got ready to SEP.

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IM THERMAL CONTROL COATING INSPECTION

SHEPARD There's one item here — IM thermal control coating inspection. I didn't see anything amiss in the IM. Did you see anything out your window?

MITCHELL It looked great. Everything was neat and tidy.

ROOSA All looked good.

MITCHELL The panels looked great.

ROOSA We saw no degradation of the IU thermal blanket at any point.

CSM HANDLING CHARACTERISTICS DURING T&D

ROOSA The fidelity in the CMS is so outstanding that I can't say enough for it. The T&D was just like the CMS. The spacecraft response, the movements, the control, the relative motion cues were all absolutely simulated to the nth degree in the CMS. It was beautiful. The only difference was that we had a better model on this day than we've had on any of the other dates. I'm not trying to badmouth the model in the CMS — it's good. It's just that on some days the lighting in there isn't what I'd like to see.

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SUNLIGHT AND CSM DOCKING LIGHTS

ROOSA (CONT'D) The attitude for docking was perfect. The Sun was never a problem. I never used sunglasses at any time and never needed any lights. The only time that the docking target was in the shadow was about the last foot before contact. Even in the shadow you could see it very easily. The sunlight was absolutely a no-sweat thing. The COAS was always visible. We didn't need the CSM docking lights.

MITCHELL We skipped that high gain antenna activation. I'd like to make a comment on that. At this point in time, the high gain antenna was functioning smoothly and without any problems whatsoever in contrast with the later problems we had with it.

EXTRACTION (SPRING EJECTION)

SHEPARD We had no problems with Hatch Installation.

ROOSA Pre-SEP and ejection went right down the line. Ed verified that our important circuit breakers were closed. The actual ejection is a three-hand maneuver in which Al and I worked together. You need to do three things at T_0 , and they all went right on the money. We got the clock started in 5 seconds. The ejection was very positive. I hit the LM/S-IVB SEP switch, and then off we came.

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EMS BEHAVIOR DURING TD&E

ROOSA I did everything by times. I didn't even worry about the EMS because it jumps around so much during that maneuver that I set it up at a minus 100. I looked at it once during the pitcharound, and it was somewhere in the area that you normally see in the CMS — about 99.6. I never used the EMS for a DELTA-V counter at all. If I didn't have it, I wouldn't have missed it, because I strictly used the time and the relative motion cue.

SOUNDS (SEP, RCS, RETRACTION, EXTRACTION)

SHEPARD No unusual sounds were associated with the process. We noticed, as we said before, the pyros are positive and very noticeable.

PHOTOGRAPHY OF TD&E

ROOSA Because we had so much trouble with the docking, I used up the whole roll of film on the docking and I didn't get any photography of the ejection. At that time, I didn't get out another roll of film. We have no 16-mm film of the ejection. I don't know how Ed did with the Hasselblad.

MITCHELL I got a few pictures, but it's pretty hard to work a Hasselblad around that television camera. I don't think we got very much.

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[REDACTED]

ROOSA The simulator gives you a very positive solenoid sound for RCS and it's not always that true. When you're attached with the LM, you can feel it shake when a thruster fires more than you can hear it. I think you could very easily get an RCS firing and not hear it. It's not quite as positive as the CMS.

MITCHELL Yes.

ATTITUDE CONTROL AND STABILITY DURING SEPARATION AND EJECTION

ROOSA Attitude control was as stable as a rock.

SEPARATION AND EVASIVE MANEUVERS

SHEPARD Separation and evasive maneuvers were just as advertised.

ROOSA I was expecting the first view of the S-IVB to be in the hatch window after that evasive maneuver, but the first view was out my rendezvous window. The S-IVB came up from behind the LM. At that point, I have a GO to the ground for the yaw maneuver. I was looking right over the LM quad when they yawed the beast. It was obvious that it was yawing and ended up almost 90 degrees to us. You could see the full side of the S-IVB and just one spot of the engine bell. You could not see the

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ROOSA whole engine bell. The yaw maneuver went fine. It ended up
(CONT'D) definitely pointed away from us.

S-BAND PERFORMANCE

MITCHELL At that point in time, the S-band was performing beautifully.
No problems at all.

S-IVB YAW AND EVASIVE MANEUVERS

ROOSA I talked about the yaw. They gave us a countdown when they
were going to do the APS evasive maneuver. The only thing out
of the ordinary I noticed was the venting. It came out of the
same vent that had been used when it was right in front of us.
We called that: They said that was normal.

WORKLOAD AND TIME LINES

SHEPARD If everything had been nominal, the launch checklist would be
perfectly satisfactory as far as time is concerned. We were
behind the time line, of course, because of the capture latch
problem. I think that the checklist is in good shape: We got
everything done right on time. Down on the very bottom of the
number 1 window, we did see the S-IVB vent, and we tried to
get a picture of it, because it had a good Sun angle. I'm

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[REDACTED]

SHEPARD not sure that we were able to do it, but we did see it visually.
(CONT'D)

It's a fantastic sight seeing that stuff venting. That last dump was really spectacular.

ROOSA It really was.

SHEPARD That last dump is really spectacular. It just fans out. The Sun was just right, and we tried to get some shots of it. I don't know whether they came out or not. It's really spectacular to the eye.

MITCHELL Our ejection sequence readouts were minus 0.7, 0, and 0. That occurred at 05:47:14.

SHEPARD How far behind were we at that point?

ROOSA Normal ejection is about 3:55.

MITCHELL We were almost 2 hours behind.


SHEPARD We're almost 2 hours behind at that point as a result of the capture latch problem.

ROOSA We were down in RCS and we had to work it back up.

[REDACTED]

████████████████████

████████████████████



6.0 TRANSLUNAR COAST

IMU REALINEMENT AND OPTICS CALIBRATION

ROOSA After we got rid of the S-IVB, we did a VERB 49 maneuver to the P52 attitude. At this attitude you couldn't use PICAPAR because the second star was occluded by the LM. This is not a big problem. It does seem, if you go to the trouble to go through a P52 attitude, that you should have one that is not occluded. I don't need to elaborate anymore on the optics with the LM docked. That's been talked about by all the previous crews. Trying to see anything through the telescope with the LM docked is very difficult. The sextant works fabulously and the P52 went fine. We did the gyro torquing with the PTC REFSMMAT. That occurred with no problems. We got our PTC REFSMMAT and went into PTC. I've forgotten what time we did that.

SYSTEMS ANOMALIES

ROOSA You can mark off systems anomalies throughout the whole flight. The CSM just purred along like a kitten. We may have had a little trouble with Myrtle, which we'll talk about later. Up to this point all the systems were absolutely in the money



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ROOSA with the exception of the probe. Communications was no
(CONT'D) problem. The high gain was working like a charm. Wasn't it,
Ed?

MITCHELL Yes, we weren't having any onboard troubles at that point.
Apparently the ground was starting to pick up a few troubles,
but we hadn't seen it yet.

ROOSA By this time, we were running late and they said to go ahead
and do the P23s. I had done a lot of work on P23s. I felt
I was well trained on them, and the first P23 went with no
problems at all. We've had a lot of discussion and many words
and data priorities on P23s. I took a day and went up to
MIT and used their P23 simulator. At the end of that day,
I wrote a critique and said this was an absolute waste of
time. Nobody up there knew what was going on. After seeing
the actual horizon, I have to admit that their slide does
look a good bit like the horizon. I understand that it is
being put in the CMS pretty much the same as they had up there.
If they do get that in, I think it will be a benefit. You
don't need the scattered light modes they have at MIT. A
good realistic slide would help. I had no trouble at all
picking up what I thought was the horizon. It turned out it
was very close to the preflight loaded value. I was

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ROOSA
(CONT'D)

consistently slow on my P23s. I knew it was going to be this way. I told people before the flight. To really get the substellar point down, it takes longer than shown in the flight plan. If you're going to shoot four stars and do two optics calibrations, it's going to take you about 1 hour and 15 minutes to 1 hour and a half. This stayed pretty consistent. I did quite a few of them on the way back. To shoot three stars and do the CALs, you should allow about 1 hour. We did the P23 and the next day we canceled the second one to save a little RCS gas. The first one went quite well. That takes us up to our PTC mode. Midcourse 1 was canceled. Then we went into the PTC and went into the tunnel. That was our order of business, I believe. We're showing the opening of tunnel.

SHEPARD

Lithium hydroxide canister change was on time. The canister change was 13:07. We were an hour behind the time line at that point, too. The tunnel must have been about that time. We're about an hour down on the time line apparently at this point.

ROOSA

The next order of business was to get the probe out and take a look at it, which we did. As previous crews have commented, the tunnel work is a 'no-sweat' operation. You're working with some big volume items, which you move around slowly and

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ROOSA
(CONT'D)

get them unwrapped from the O₂ hoses. That went pretty well. We did some specific checks on the probe before we removed it. We got the probe and drogue out. We looked it over and could see nothing particularly wrong with it. We went through all the checks on the capture latches. They all worked good. We put the probe back into the tunnel in the stowage configuration and felt pretty warm about the probe at this point. What was wrong is still a mystery to us, but it checked out real well. We stowed the probe again as per the decal. The decals, as on all of the flights, worked fine. They're in the right place and they say the right thing. We really didn't do any television on this day, nor really take any pictures.

The P52s during PTC went just as advertised. The optics drive in the spacecraft's a little better than the CMS and used medium speed. I might as well comment here on the frustrating thing as far as five zeros and 00001. You can work your behind off and get five zeros, or you can work your behind off and get 00001. I never did psych it out in all the sightings that I made. You shoot into the Sun and get five zeros, and you shoot into the dark steady as a rock and get a 00001. So, I refuse to comment on that.

SHEPARD When you want five zeros, just call the CDR to do it.

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[REDACTED]

ROOSA That's right. When you get too frustrated, Al will come down and give you five zeros. When I started out, I was going to try to keep a running tally of five zeros versus 00001. I gave up. I'm not sure how I made out in the overall scheme of things, but the alinements were all right.

SHEPARD We had a good platform though. Man, that PTC!

ROOSA It was really beautiful.

SHEPARD Beautiful platform.

CM/LM DELTA-P

ROOSA The first LM DELTA-P read-outs were not too significant because we went into the tunnel pretty soon. The LM was tight, too. You know that usually held good.

SHEPARD Yes, it was.

ROOSA It really worked out fine.

ODORS

ROOSA As far as odors around the probe and drogue, we commented on that. I guess we're about up to the end of that first day, aren't we, where we trouble shoot the probe and we're ready to go to sleep? It was a long day.

[REDACTED]

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SHEPARD I think so. I don't see anything in the flight plan we haven't discussed. We did the presleep checklist, and all that good stuff.

RESTING, EATING, COMFORT, HOUSEKEEPING, AND EXERCISE

ROOSA I guess we've got some comments here. Resting, eating, comfort, housekeeping, and exercise. I guess everybody can take a hack at those.

SHEPARD We'll try to cover that for the whole flight so we won't have to worry about it again. Food preparation — we won't talk about that then. As far as the exercise was concerned, we missed the first day because we were behind in the time line. I was going to try to get all the exercise periods. We hit them all on the way out; other than the first day. Also, I was going to try to drink a lot of water and eat a lot of food, so I wouldn't lose any weight. I think we were able to do that fairly well. We'll save our specific comments on the food until we get to that section later on. And, I think that as far as the general housekeeping was concerned, on that first day we were a little behind schedule and a little sloppy in our housekeeping; but we soon caught up on that. That picked up the second day. As far as resting is concerned, I found that it was difficult for me the first couple of days to relax,

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SHEPARD
(CONT'D)

particularly my leg muscles. I guess the legs are such an overdriving influence in Earth's gravity that I generally tried to hold on too hard during zero g with my legs. I found during the first couple of days I was very tired in my back and leg muscles, as a result of involuntarily hanging on with my feet, toes, knees, everything else, even when I was resting in the couch. After the first couple days, I had no real problems. That did affect the ability to sleep, however, for the first couple of nights. After that, I found that I slept for long periods of time. I'd sleep fairly well for a couple of hours at a time and wake up, readjust, and use panel 251 or whatever was required over there and then go back to sleep again. The sleep seemed to be fairly good, and fairly deep when I was sleeping. But, I never seemed to sleep for more than a couple of hours at a stretch at any given time, except the night after TEI we slept pretty well. Those are my general comments, about that section. Ed, do you want to take over?

MITCHELL

Well I'd like to echo Al's comments about the tiring in the legs and back. I noticed this too. I noticed it throughout the flight, diminishing toward the end. I found the exercise helped quite a bit. It felt good to pull on the Exer-Genie, and straighten those muscles out. And I had the feeling, a subjective thing, kind of like when you get the flu. You know,

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MITCHELL those muscles feel pulled and achey and kind of tired. It felt
(CONT'D) good to stretch them. As far as sleeping was concerned, I had
the same experience Al did. I could sleep for 2 or 3 hours,
seemingly very well, and then it was in bits and snatches
from then on, an hour and a half or so at a time. And I found
myself feeling rather insecure and not sleeping too well in the
sleep station in the hammock. I wanted something to touch or
hang on to. I found later that I could sleep better strapped
in the couch — more soundly, I felt — strapped in the couch
than I did in the sleep station. Now Stu, I think, is going to
say just the opposite. So it apparently varies with the
individual. But I felt that we were getting adequate rest
throughout the job, but I would like to have had more sleep
to feel really refreshed. Other than that, it was quite com-
fortable. Again, the exercise seemed to do a great deal to
make the comfort a lot better.

SHEPARD We rotated around and took turns on the comm when the three
of us were there. I think I probably slept better with the
comm off than I did with the comm on.

ROOSA Yes, I don't think it's where you're sleeping, it's having
that comm on that bothers your sleep, whether you're in the
couch or not. As far as resting in the couch, that was a

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ROOSA
(CONT'D)

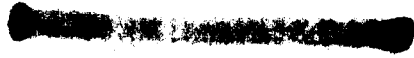
hangup for me. I guess I laid in the CMS for so many hours that whenever I was in that couch, I instinctively wanted to try to hold myself in it. The first night I put a lap belt on, and I didn't rest too well. Finally, I would not put a lap belt on or anything, just float above the couch, close my eyes, and assume I was hanging up in the tunnel. I found out that I could rest — the best place I found in the spacecraft to rest was with my feet sticking up in the tunnel and my head hanging down by the optics panel. That was the way I felt the most comfortable. Whenever I was in the couch, I was always trying to assume a one-g position on the thing, instead of just letting myself relax.

MITCHELL Which, I guess, goes to prove that it's very much dependent upon the individual, as to how one rests.

ROOSA Yes.

SHEPARD We're up to about 26 hours in the flight plan: postsleep checklist and the read-outs of the dosimeters. We had one dosimeter that failed. It was Ed's personal dosimeter. We substituted Stu's, and pressed on. LM/CM DELTA-P at 27 hours was 0.3.

ROOSA P23 was canceled.



ROOSA No. A few tenths.

SHEPARD A few tenths of a second. What was the pad on that?

MITCHELL The pad's right there.

SHEPARD Burn time was 10 seconds. The DELTA- T_{ig} was 0; burn time was 10.0, actual burn time; VG_X , 71.7; residuals, plus 0.2, 0, minus 0.1; DELTA- V_C , minus 4.1; fuel, 100.2; oxidizer, 98.9; unbalance, decrease 300; and pad burn time was 10.3, only about 0.3 short as near as we could tell on burn time. But everything went as advertised.

ROOSA Burn 1 was a rapid kick in the seat of the pants; the SPS kick felt good. One other comment: my P_C throughout the whole mission was riding a little lower than what I had seen in the simulator. Everything else looked very good, the burn times and DELTA-Vs went very well. Just the P_C seemed to be hanging right around 100, instead of, like in the LOI burn in the CMS, 105 or a little over. Other than that, it went extremely well.

SHEPARD It didn't correlate with the burn time being slightly short. Anyway, it looked like the residuals were real good and there were no questions on that burn. You want to cover your dim-light photography?

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ROOSA I don't have too much to say about this dark-side photography except that I was surprised as to the amount of scattered light in the sextant. I asked about this situation, because I was sure I had the sextant where MCC wanted it; I took the films just right down the checklist. MCC gave two different attitudes. They had updated to the longitude over 2, a little different. We took one series there; when I commented on the scattered light, MCC said to go back and take another series on the preflight longitude, so I did. Both attitudes looked like they had about the same amount of scattered light in it. How the film has come out, I don't know. It was a very simple thing to do. It was a no-sweat operation. The sextant just picked up a lot of the scattered light.

SHEPARD Then we went back into PTC again at 31:30 with no problems. We made the crew exercise period at about 32 hours.

ROOSA Here also, we used the same dim-light procedures on trying to get some pictures of the S-IVB. I questioned the validity of using those procedures, but that's what MCC wanted, and that's what we did. It seemed like they should have been shot at something like one frame/sec if you really wanted to catch it instead of the one frame at 60 and so forth. But, anyway, it was something to amuse us and the FDOs I guess; so we took

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ROOSA several shots of the S-IVB. I have no confidence at all
(CONT'D) that the film will be any good.

SHEPARD We finally completed this S-IVB photography technique at
34:03.

ROOSA I think we also took some at 32:45. We took a couple of
series of those. And then we got out the big Hycon camera,
unstowing that beauty, installing it and going right down the
decal, and everything went well. We got the magazine on there,
it checked out just as per the checklist. It was a no-sweat
operation. We changed the magazines, and we were all set for
the low altitude pass at Descartes.

SHEPARD All right, canister change at 38:20. LM/CM DELTA-P was 0.8 at
38 hours and 30 minutes. I have a comment that all of us
dozed a little bit around 38 hours. Not simultaneously.

ROOSA Were you noticing all these five zeros on these P52s going
through about here?

SHEPARD Yes. I noticed a few of those. I didn't realize you had
that many, Stu.

ROOSA We went to sleep that night.

[REDACTED]

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SHEPARD That takes us into the following day, 51 hours: the postsleep checklist and the updates. Everything went on schedule as far as the time line was concerned. At no time did we use any of the medication in the medical kit. Ed and I used nosedrops a couple of times to clear up the stuffy feeling, but at no time did we use any of the medication.

ROOSA My head cleared up pretty well after the first day or a few hours, whatever time it was, and stayed relatively clear until just before entry. I thought I would use some of the nosedrops and I did. I was sure glad I hadn't used them before because once was enough. I didn't like those beauties. They made my eyes smart and everything else. After the original stuffiness, my congestion went down, and my head felt good the rest of the time. I sure didn't like those nosedrops.

SHEPARD All right. We went through the bistatic radar check. We didn't have anything to do with that except throw a few switches. We did that. There's another five zeros there. Is that the one I did?

ROOSA Well, that's your writing.

SHEPARD We just came upon a note in the flight plan. At 54 hours, we had T_{ephem} update and we loaded it like everybody told us to. When we read it out and it wasn't the same thing, we had

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SHEPARD
(CONT'D)

some conversation about that with the ground. They said it was fine, but I must admit that it was a surprise to us because we never had seen that before in any of the sims. We just wanted to bring that to everybody's attention, but I think it ought to be the same.

ROOSA

It surely should. They came up with a good explanation — that if you are a fast man on the octal slide rule, you can add up all those numbers and they will come out to be the same total value, but that's not the way to do business. The pad value and what's in the CMC ought to be exactly the same, and none of this Mickey Mouse even though it adds to the same amount.

Enough said about T_{ephem} . We had simulations on that and we had not come across this problem. Hopefully, if we have any more T_{ephem} updates, the pad will look like the CMC value. Other than that, T_{ephem} went well and it surely helped me out in lunar orbit — not having to make all those time changes. That would have really been a drag.

After the T_{ephem} , we went on and shot some more pictures of the S-IVB. Same story. It looked like everything was just ginning along. The null bias check, I really didn't get any good rhyme or reason on that thing. We did the null bias

[REDACTED]

CONFIDENTIALROOSA
(CONT'D)

check and passed the values to the ground. We took what they gave us for DELTA- V_C on the pad and didn't mess with it. Mid-course 3 was deleted. We moved up LM activation by an hour. I've already commented on the hardware in the tunnel. We'd already had plenty of practice with it, troubleshooting. This is when Al took the CM 18-mm lens and a magazine over to photograph the dump. I had him sign a hand receipt here in the flight plan (laughter). That was rather spectacular. I bet those pictures are good. This was in addition to the normal going in and looking over the LM. They took some pictures of a CM waste-water dump through the LM window. Those dumps are spectacular. They should turn out pretty good.

SHEPARD

When that waste water comes out of there it's like being in a blinding snowstorm. It really zaps out. It came out with a pretty good velocity. Most of it drifted away fairly rapidly. Some of the stuff that hung with us was the tail end of the dump — just spitting out, freezing, melting, and departing with low velocities. The urine-dump departure velocities were lower.

ROOSA

They were always with us. Venting from the urine dump was a real problem if you're going to do a P51. I'm not sure

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ROOSA
(CONT'D)

[REDACTED]

whether our heater was working exactly right or not. Every-time we would dump into the Sun, we'd flake off a few flakes and they'd be out with us. One day during PTC, I became well dark-adapted with the patch, kept my dark adaptation, looked through the telescope, and all I could see was a million stars coming from our vent.

So, all the time during our wait periods, we would be kicking off this vent almost continuously when it went into the Sun. One day, I guess it was entry day or the day before, and before we had done any dumping that day, I looked through the telescope and it was great, with the Sun behind me. Of course, the LM was gone. But, with the Sun right behind me and with no vent you could see the constellations. You have to be going down across the south. You could see Acrux and Atria and so forth. If you're ever forced to do a P51, I think you're going to have to stop that urine dump hours before you get ready for it. You're going to have to go to bags 10 hours or 5 hours, or some long period of time before that to get rid of the residual dumping that you are faced with.

SHEPARD: I think that's right. If you've got a planned P51, if you know ahead of time that you're going to have to do it, then you're all right. But, if suddenly you have to do one, and

[REDACTED]

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ROOSA (CONT'D) you've been going along dumping, like you normally do, I think it'll be awhile before you get it. As a result of that, we were very religious in keeping that GDC alined every time we could. We didn't have too much drift; but, even so, we'd be tweaking it up all the time so we get a good backup alinement. Good enough, we felt, so we could run a P52 if we had problems with the platform. That venting was amazing; it really surprised me. I hadn't heard anybody comment on this before. I had a very low confidence level in being able to get a P51 without several hours' wait.

MITCHELL There's not a great deal to report on LM housekeeping. Everything progressed quite nominally. Of course, we had an ill-fated television show about that time.

SHEPARD The tunnel-index angle was 0.9 as the CMP pointed out several times.

MITCHELL He'd never let us forget that.

ROOSA It was less than a degree.

MITCHELL The television camera in the LM, as you're probably well aware on the ground, simply didn't give enough light to make a decent show. It threw all of our plans into a cocked hat. Unless we can come up with some way to get better lighting or open that

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MITCHELL television up more, I would strongly recommend we not try
(CONT'D) that anymore. Everything else went very nominally except, of course, the battery problem that showed up at this point. The onboard indication confirmed precisely what the ground was showing. We were about a half a volt low on ascent battery 5.

SHEPARD The battery problem developed before this time, right?

MITCHELL No, sir; because it developed at this point when we first powered up the batteries.

SHEPARD No. We had gone into it the day before.

MITCHELL No, sir. This was the first time. Nobody looked at it. Nobody had any idea that the battery was down before this. I must point out that the descent BATs were put on high-voltage taps about the time we called them out on the checklist because, although that's supposedly a flexible time, the voltage actually went below 27 volts at about the time I got to page 114 in the Activation Checklist on the TLC day (on housekeeping day) which surprised me. I expected them to hold the low-tap voltage much longer than that.

Comm checked out well. We pressed on through the OPS checkout on that day. I reported 6200 pounds on the Commander's OPS and 6000 on mine. We then transferred the power back.

[REDACTED]

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SHEPARD There was a couple of those very small screws and a few small washers that were floating around in the LM. It wasn't quite as clean as the command module. We really saw no parts of the command module that I can think of, that were floating around when we first became weightless. But, there were a couple of small washers and small machine screws in the LM.

ROOSA I commented on that during the TV show. I hope the people that were involved at the Cape and so forth heard it. That spacecraft was clean. Just really beautiful. We had nothing at all loose in there.

MITCHELL We transferred to LM power at 62:21:14, and pressed on through with the only anomaly being the low BAT 5 voltage. We transferred power back to the command module at 63:00:45, and that terminated the first LM inspection.

Doing as much work as possible on that housekeeping day certainly made it a lot easier on PDI day. Getting equipment stowed, getting the cameras set up, or the first camera rigged with its brackets and triggers certainly simplified the tasks on PDI day. I heartily recommend it to the following crews. Other than that, it was totally uneventful.

ROOSA Even gave the CMP a chance to get his head into the LM.

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SHEPARD Stu came down and watched the dump while we were taking pictures of it.

ROOSA It was pretty. While you were in the LM, I was getting the probe and drogue out so we could take some pictures of them. After you came back in, we maneuvered around and took some pictures of the latches and so forth. As it turned out, we brought the probe back, so the photographs don't mean much. Then it looks like we went to sleep.

SHEPARD Right. The usual presleep checklist.

MITCHELL And that disturbs the sleep right there.

ROOSA After we got up, they had thought about this T_{ephem} routine at Mission Control. They had us reload our CMC value of T_{ephem} as per the pad. That made us feel a little better that we both had them looking the same.

MITCHELL While we're on that subject, there was a couple of places where the two computers in MCC didn't really talk to each other; they came up differently — the load and the pad in one case, and the T_{ephem} in the other case.

ROOSA Yes, it was just T_{ephem} which we've dwelled on, and the other time was a 0.1-ft/sec difference.

[REDACTED]

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MITCHELL Actually, it was kind of insignificant, but, at the same time, it was disconcerting to see it.

ROOSA Then the next day, after we got squared away, we maneuvered to this Moon-view attitude; boy, if that isn't spectacular, homing in on that beauty and looking at it out the hatch window.

SHEPARD I don't know if there's any sense in talking about midcourse. We had no problems there. Midcourse 4 went as advertised. We didn't have any problems with the pad on that one, did we?

MITCHELL No, sir.

SHEPARD We used a minimum-impulse burn, and it went off as advertised. Residuals — well, DELTA-V_X was 4.8 and residuals of plus 0.3, 0, minus 0.1; DELTA-V_Z minus 2.6. There was no change on the fuel and oxidizer from the previous burn — one quick look and that was it.

ROOSA We were very pleased with the minimum-impulse burn on the SPS.

SHEPARD We were happy then, because we were concerned about being down on RCS budget. We were happy when they decided to go ahead with SPS minimum impulse on that because it saved us that much more gas. So that worked out fine.

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SHEPARD I was just noticing here we said the tunnel closed out at
(CONT'D) 79 hours and 5 minutes. We didn't say when we opened it up,
did we?

MITCHELL Well, we opened it up during the television period, Al. We
opened it up in real time. This was the first time we went
in.

ROOSA No, the second time.

MITCHELL Second time, okay.

MITCHELL This was the impromptu entrance when we went in for trouble-
shooting. It's right here in the script.

SHEPARD We don't have anything about that quick visit to the LM that
wasn't discussed over the air.

ROOSA Well, I'll remember the time period between 80 and 81 hours.
That was the hour that I had set aside for the little blue
bag.

SHEPARD We took some lunar pictures per the flight plan at 80 hours.
The DELTA-V test and null bias check were on schedule. Every-
thing was according to the flight plan. And I guess we're
just about ready for LOI.

[REDACTED]

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MITCHELL I don't believe that we had any high gain antenna problem up to that point. We'd been on OMNI's except for the times we were on television. They were locked on for those short periods without much trouble. Our high gain antenna problems didn't occur until lunar orbit generally. I think it's really a distance problem; and there's nothing sacred about the lunar orbit bit. On this high gain antenna, I got plagued with that quite a bit. Of all the simulations, of course, the comm is the worst ones that you can get in the CMS. The high gain antenna performance, as simulated in the CMS, is much too good. It doesn't make you work hard enough to get that lockup; in the real world, a very slight change in high gain antenna angles (1, 2 or 3 degrees) means the difference between having the lockup or not. This is not the case in the CMS. Concerning the CMS, you get in the area, you get a good signal strength, you go to AUTO and WIDE, you zap it down to NARROW; and, man, you're locked up solid. It doesn't happen that way in flight. It was a little surprising that such a small change on that high gain antenna position could mean the difference between a good signal strength and an unworkable signal strength. When they pass numbers for the high gain such as minus 53 and plus 69, you really want to work at trying to get exactly on those numbers. Of course, everyone

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MITCHELL realizes that you can't read the gage that accurately. You
(CONT'D) get there and then use just very small corrections to tweak
up. It really makes a difference.

SHEPARD No PTC problems. No problems of removal of probe and drogue,
this time.

[REDACTED]

[REDACTED]

[REDACTED]

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7.0 LOI, DOI, AND LUNAR MODULE ACTIVATION

SHEPARD We went through the CSM systems checklist at 81 hours 10 minutes like we were supposed to. No problems.

MITCHELL During the systems checklist Pre-LOI RCS quad readings, in order, were 3850, 3650, 3750, 3850. Quantities were 85, 87, 86, 87, and temps were 77, 74, 65, 76. The SPS readouts were somewhat meaningless since there had been no PU management during a midcourse, but they were oxidizer 98.9, fuel 100.2 with an unbalance of 300 decrease. I think that's about, ... as far as I know, Al, it's about all the prep for the burn. We found nothing about the prep that was unusual or even exciting. It's very routine.

SHEPARD Okay, as far as the burn was concerned, everything was nominal. The only item we didn't read down in the burn report is VGX was 30 23.9; CMC showed a 169.6 by 58.9 orbit. Everything else in the burn report has already been shipped to the ground, and you want to comment about the PUGS?

MITCHELL The PUGS indication was entirely different than expected. There was no sharp indication of crossover at all. At the beginning of the burn, the PUGS did settle out at about a minus 150 as expected. It was controlled about that point using the increase and normal positions. As we approached crossover,

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I was expecting to see the PUGS oscillate wildly to the INCREASE position. It did not do this; there was a smooth transition up to the green band of the unbalance meter, and it stabilized out around zero without any oscillation whatsoever. It was subsequently controlled about that point with the INCREASE and NORMAL positions of the switch. It was an extremely smooth crossover that was just not noted on the indicator at all.

ROOSA

I would just like to say another word or two about the PUGS. It was downright irritating. I made a big point of this PUGS operation prior to flight, trying to make sure that we got the right briefing on it, because I was getting two different stories on how the PUGS was going to operate. I made a comment on it during one of the SIMS, and FOD got everybody together for a briefing. The PUGS didn't act like we were told it was going to. I did run some LOI's shortly before flight on the CMS looking specifically at the PUGS. The PUGS operation in the CMS was exactly the way it happened in flight, which was not the way everybody had briefed us that it was going to be. So, once again it was CMS score one and the other side zero. Also, the PC didn't increase, didn't jump its 2 or 3 psi at crossover, and I think this goes right along with the PUGS operation. The unbalance didn't shift and PC didn't shift.

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ROOSA (CONT'D) So we were looking for crossover on the time. This was the approximate time of the crossover in the flight plan so we were both looking for it, and I didn't see the psi jump. It did not jump, as a matter of fact.

MITCHELL The only other comment I have on the burn is a subjective one. The acceleration onset when the engine went off was a little bit sharper than I expected. It was very noticeable. I suggest everybody be prepared for that, because after 3 days of zero-g it does somewhat surprise you.

SHEPARD Did you strap in for the burn? I don't remember.

MITCHELL Yes.

SHEPARD Right after that we maneuvered to comm attitude and made the burn. And there we sat, looking at the lunar surface, and it was spectacular. Actually, all three of us had a window at that point. Ed and Stu had the maps and started reading off to me the craters, and everything was about as advertised. Even though you maneuver looking at the Moon on the way out-bound, as you approach prior to the LOI burn, it's kind of a gee whiz thing. You know, look how big it is and how fast you're getting in there, nothing objective at all on the observations. After you've made the LOI burn, you're really

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SHEPARD (CONT'D) interested in being able to establish where you are on the ground track versus the photos or versus what you've remembered. I think it's probably a pretty good idea not to plan too much during that first orbit so you can have a chance to get settled down and look at it because it sure as heck does look different. It doesn't look like flying at 20,000 feet over the Earth. You never worry about the height above the ground when you're flying over the Earth because it's very familiar to you. But - there's nothing to compare with it unless you've been to the Moon before. There's nothing to compare with that ability to discover how high you are above the surface. I think that that pass to get settled down and look at where the ground goes by and get oriented really is a good one. We did a P52 there and again the torquing angles were very small at 84:10.

MITCHELL We were using both types of maps, or both maps, when we were taking our first look. One of them we found fairly satisfactory and the other one totally unsatisfactory.

ROOSA What Ed's talking about is a contingency map and it's no good at all; everybody knows that. You don't use it much unless you're in some oddball situation. The two orbital track maps are both the same.

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[REDACTED]

MITCHELL They're both good.

ROOSA One is for one day and one is for the next day. It ended up that Ed had that contingency map. It wasn't any good, but that's no big deal.

SHEPARD Okay, then we get around to landmark track. Okay, we had no problems getting ready for it. I think that that's a good idea of putting the camera configurations in the flight plan at this point, because it just flows naturally in the time line and you get everything ready to go.

MITCHELL It certainly saves us pulling another book out on schedule here.

SHEPARD I've got some comments about the total flight plan later on, but I think as far as the inclusion of the camera settings here; it's a good idea. So we had no problem with that — landmark tracking.

Okay, at 86 hours again we went to the systems checklist prior to DOI burn. There was nothing unusual about it. Did you have any problems with the pad on DOI coming up?

MITCHELL Not that I'm aware of.

SHEPARD One general comment about these sextant star checks that we ran and that has to do what Stu commented about the P51 failure.

[REDACTED]

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(CONT'D)

The way that things are planned and the way it's run in the CMS, there's no question about the fact where the star is because there is either enough dark adaptation or the star ball is bright enough in the CMS so that you get a good cross check on the actual star identification through the telescope prior to looking at it through the sextant. During the case of the flight, in almost every case, neither are you dark adapted, nor are you in position where you have time to get dark adapted and positively identify the star through the telescope because of the external lighting and particles. So about all you do in that one is let the optics drive and if there is a star in there you assume its the right one and take a whack at it and see if it meets the rules.

If your platform's good enough to acquire the star, what's the sense of doing it? Or, if you really think you need a star check, then allow yourself enough time in the flight plan to positively identify it, which means being dark adapted, no urine dumps, and so on. So, although we passed the star checks in every case, it's the kind of thing that gives you a little confidence but not one we could positively say, "Okay this is star so and so," like you can do in the simulator.

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[REDACTED]

MITCHELL We had no pad problems as far as the DOI burn was concerned.

SHEPARD Okay. So, I guess as far as the prep for the DOI burn was concerned, we had no problems. The items that were not reported in the burn status report were VGX was 206.9, and the CMC and MSFN was 9.3 by 59.0. One thing that we prepared ourselves for — I thought very thoroughly before the flight — was to be in a position where we would not overburn DOI. We were prepared to shut off exactly at burn time when she was passed, not only in seconds but also fractions of seconds — tenths of seconds. And I felt we were adequately prepared for this particular case. As a matter of fact, I think we ran one of these in the simulator just prior to the flight. I had something like four failures in the CMS to make us overburn — which was something we felt was not real world. So we felt like we were adequately prepared against an overburn for the DOI. This had been the subject of a lot of consideration, and we felt in good shape on that.

I believe Stu's comment was that PC was already coming down at the time that he punched the ball valves. So, although it was a G&N shutdown, we still felt like we were in good shape as far as being backed up in the manual shutdown. Isn't that about the way you saw it?

[REDACTED]

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ROOSA Yes. In fact, I think they called and wanted to verify for sure that it was beginning to shut down and PC was falling through about 25 when I closed the valve on the count.

MITCHELL You might comment that the actual burn time as clocked was 20.6 as opposed to the pad burn time of 20.8. I think we all probably had the same impression. I had the impression that it was either simultaneous shutdown or that the G&N just barely beat it.

ROOSA No. There's no question but what it was the G&N.

SHEPARD I'll verify that.

The technique was good. I think we ought to practice that because it's one thing that's going to be facing us all the time. It is critical not to overburn, obviously. So my suggestion to the subsequent crews is to sort out your procedures and be damn sure you know what you're going to do on those DOI burns. That's about it for DOI. There we were as advertised.

ROOSA That's a nice orbit.

SHEPARD Yes, but it does look low, doesn't it?

ROOSA It does look low. When you look out at the horizon those dark craters on the horizon with their rims, they look above you;

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ROOSA
(CONT'D)

they really do. You have never seen 40,000 feet look that low. I don't think it was any concern as far as being in a low orbit, but I think we were all surprised about how close we appeared to the surface. It's a nice orbit and going into the terminator in that low orbit is really something.

SHEPARD

Okay, from here on out, we stayed on the flight plan. We get to the point where we start to break out the Hycon. That came out as advertised; we practiced that a number of times. Actually, all three of us at this particular point got it out with no problem at all. At 89:15, it got noisy; we were kind of haggled about a strange noise in the magazine.

ROOSA

Okay, so we got the Hycon out and we got the attitude in plenty of time. There was nothing rushed at all about this time line. After the DOI, I do have this low altitude landmark which I just looked at; I did not track H3. Low altitude landmark tracking is a lot easier than what I, or I think anybody, envisioned it would be. In this case, even holding in inertial attitude, coming across the landmark, you can track the landmark completely around nadir and on out. Then, in the actual low altitude landmark pass where you torque the spacecraft to 2 deg/sec, this helps out your problem and makes it a "no-sweat" operation. This was no problem at all for H3.

CONFIDENTIALROOSA
(CONT'D)

Then coming from H3 into the Hycon, we had plenty of time to get it set up. We had it up and checked out in detail. I thought the decals were really good. With three people in there, it's difficult for one to get over to see the decal. So, in this case, Ed, we read the decal and we went thru the rest of it. Then we started clicking off for the low pass on Descartes, got to about 140 frames on the counter, and got this strange noise (of which there had been a lot of talk) in the camera. We don't need to elaborate on the noise, since we've already kicked that around. But anyway, this malfunction started at 140 frames and went to 180 and stopped. These are plus or minus a few frame counts. We were clicking them off pretty fast, and it started again, went away, and started again at 240 frames and continued right on to the end of that film pass up to when we were reading 420. That was the first indication that we might have some problems with the Hycon. We finished up the pass and did a little troubleshooting there. We used another seven frames or so trying to clarify to Houston what the problem was. I changed the magazine at this point and put on another magazine and then went through the procedure that Houston had read out. The trouble still existed. This was the time that we realized that the trouble also existed with the mode switch in STANDBY. We had the power switch on and the mode

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ROOSA
(CONT'D)

switch in STANDBY. You would get this noise, which later we discovered to be the shutter operation. The camera was clicking away, in STANDBY. We troubleshot on Mag B, and I used up about 23 frames in Mag B. I relayed all that info to the ground and then we got ready to go to sleep. I was looking at the camera and not outside. I have no idea. The FAO people would know very easily. They could take this T-start time and, with the intervalometer clocking about 1 a second, set at 65 - we were approximately 2 minutes into the pass at about 140 frames when the trouble started. They could very easily find out whether or not we got Descartes trouble free or not, just by those frame numbers. Those frame numbers, of course, are plus or minus a few because I'm reading the counter as it's clicking and writing them down.

SHEPARD One thing we skipped over here, after the DOI burn, of course, we had maneuvered to the bailout burn attitude, and, although it was superfluous in this particular case, it's still a maneuver that has to be started right after DOI, in case your bailout burn is required. It's something that has to be done and the crew ought to practice it that way, because in simulation for example, where you have to burn, you just don't have time to do it in a hurry. So, that maneuver has to be started right after DOI.

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ROOSA I've got one comment, Al. Just prior to going to sleep, we were having trouble with one of the sensors and we had to do the same check that you had done.

SHEPARD Okay, I guess we can just make the comment here, because we might forget to do it later, that both Ed and I had problems with our sensors. Both of us had leaking electrolyte through the cup or around the cup, and that disturbed the signal. Later on, the square plug, where the sensor wires connect into the signal conditioner in the bio valve; the threads had stripped on that, and of course that ended my EKG the last couple days. But that is after the fact as far as the mission is concerned. We'll cover that in more detail a little later. We had discussed getting ready for the following day, and I think it wise, before you go to sleep that night, to be sure that you've done everything you can to be ready for PDI day. Because there is no question, as far as the LM and CM are concerned, it is a busy time line and I think we felt that night that we looked ahead and had a pretty good handle on what we were going to do. The equipment to be transferred was already out.

MITCHELL Might I add whether you get it out or not, it's important at least to be able to identify you know where every item of it is so that you could lay your hands on it readily the next morning.

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[REDACTED]

SHEPARD We did all that and we still didn't get too far ahead of the time line for the following day.

ROOSA I had a little luck that night when I sacked out. I was putting up the window shades and crossing into the terminator, and I got a real good look at my low altitude landmarks — my 14-1, 2, 3 and 4. They came right over at that time; they had moved right out of the terminator, and it looked like we were smack dab on the top of it. Luckily, I was just putting up the window shades and there they were, right out the window, just by the terminator.

SHEPARD Okay, let's just recap here and see if we covered everything for LOI and DOI, because it looks like we're at that point. Does anyone want to say anything about the sounds of the SPS?

ROOSA No these two burns were nothing unusual.

SHEPARD Ed had commented about the acceleration. Gravitational effects on spacecraft attitude should read gravitational effect on the attitude of the crew.

MITCHELL I don't think we were ever in a stable position long enough to be concerned about gravitational effects on the spacecraft. I never could determine the gravitational gradient alignment, but I'm sure it exists if you sat there long enough.

[REDACTED]

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SHEPARD I think that's right. I don't think they're particularly interested in those, because the way the spacecraft was being controlled, moving from one attitude to another, for one purpose or another, the gravity gradient certainly would be something other than what we could determine.

ROOSA In realinement of the IMU, all those which we did, cislunar or with the LM on, we gyro torqued and it went well. One of us would watch — we watched the attitude we were going to — to see if we would have gimbal lock problems. We watched the ball while we were gyro torquing, and it worked out real fine.

SHEPARD We had no problems with Comm.

MITCHELL As I recall, we probably started having a little bit of problem with Hi gain, and I think we had to go to the voice tapes to find out exactly what was happening. We can summarize it by saying that we seemed to be having trouble in the auto track position of the Hi gain, and I believe it was on the primary servo electronics. Rather than trying to reiterate any of that, I think the voice tapes will give the best record of what actually went on, but in summary it seemed to oscillate and not maintain a stable lock-on.

SHEPARD Let's see, do you want to talk any more about the Descartes photos?

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[REDACTED]

ROOSA No!

SHEPARD We had scheduled a television pass for this day and, after some discussion preflight, decided to cancel it. I think we mentioned during the flight, during that time period, that we were glad that we decided to cancel that TV show. It was just too busy a time period and, most important, it turned out later to be a bad attitude for viewing the landing site. So, I think it was a good decision to cancel it, prior to the mission. Okay, concerning PGA donning, here again we have that sensor problem which we had discussed and we're at the point where Ed had taken his sensor off and put some more electrolyte in there and glued it back on again. For some reason, it didn't have high bit rate and we couldn't check it prior to LOS. That time they said hold off on the suiting till we could check it on the next pass. We decided we didn't want to do that and I'm glad we continued ahead with the PGA donning. Otherwise, we wouldn't have made it. As it was, we were only a few minutes ahead of the time line for Ed's IVT into the LM, and I think that if we'd waited to check that sensor that we would have fallen behind.

MITCHELL The ground suggested we change out the harness. There was no time to change out the whole harness and it's well we did not

[REDACTED]

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MITCHELL do that. As Al was pointing out, we barely had time to go
(CONT'D) ahead and change that one sensor, without checking it out. So,
we went ahead with the donning. Fortunately, we changed the
right one and it worked out well. The reason we weren't getting
a solid checkout was that the Hi-gain antenna was oscillating
and was not getting a solid lock-on on high-bit rate. We
guessed right and it worked out okay but it could have been
sticky if we had waited a bit longer.

SHEPARD Did you have any trouble donning your PGA?

MITCHELL No. I would like to make a couple of comments on the way the
two of us went about doing that. Getting into the PGA in
zero g is reasonably a "no sweat" operation. We utilized the
tunnel as the donning station and one at a time positioned the
PGA in the tunnel, and then just slid into it, with the other
crewman helping to pull up the zipper. It worked out very
smoothly. The tunnel makes a very nice donning station in this
case, with the second crewman helping maneuver the zipper. I
guess Stu might have some comments since he did do his by
himself.

SHEPARD It was originally planned that I was going to try to help Stu
but, by the time he got to putting his PGA on, it was time for

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SHEPARD me to go into the LM. We don't have any notes here as to
(CONT'D) where that happened.

ROOSA I don't think there was anything that was holding us up. I cleared the tunnel before I put on my suit. I cleared the tunnel early and that was what it was. So, we had the tunnel open and everything ready to go. Then I got the suit on and that was it.

SHEPARD Well, did you have any problem getting your suit on?

ROOSA No, not at all.

SHEPARD I guess the point is that it is preferable to have one of the other two crewmen help the CMP, but in the event that the time line does not permit it, then he ought to be donning himself.

ROOSA I don't think you need to plan on helpers because the CMP's suit is lighter and easier to handle than the other two. During all the suit donning that I did in preflight, I always donned it myself using the lanyard, so I was well trained. The suit goes on easily. It's a 2- or 3-minute operation after you remove the suit from the bag so there is no reason at all for anybody to wait around to help the CMP.

SHEPARD For the record, Ed will start again with the power switchover at 101:54.

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MITCHELL I had hoped to have a little bit of pad on that time when we went in but, due to the slight holdup on the sensors, we were right smack on the time line. I don't recall that we ever gained any time on the time line until very late before docking.

SHEPARD Did you have any problems with the tunnel open at that point?

ROOSA No, we'd been in and out of the tunnel several times at that point. There were no problems on any of the tunnel work. The docking tunnel had not slipped any during the LOI and DOI burns. The roll angle was exactly the same.

SHEPARD Okay, so no problem with the tunnel mechanics and pretransfer operation. Concerning the IVT phase itself, there were no problems. Of course we yelled back and forth a couple times during the tunnel activity to be sure when the drogue and the probe went back in that the latches had properly captured.

ROOSA The decal calls for two checks. One when I first install it and one just before I preload. And both times, it looked good. I had no trouble hearing through the tunnel.

SHEPARD We tried this twice, just to make sure of the probe operation. We tried a couple of times just to be sure that the probe

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[REDACTED]

SHEPARD operation, and capture latch operation were normal. Prior to
(CONT'D) that time, we checked the preload and it did in fact work normally both times.

ROOSA They did call us and you took a tool R with you.

SHEPARD As far as the condition of the CSM thermal coating, we had in fact looked at it before because we'd been there a couple times and noticed no problems with it. As a matter of fact, I didn't see anything that looked unusual in any of the visual observations of the CSM at any time.

Concerning LM entry status checks, transfer of equipment, and housekeeping, the general comment can be made that the night before you ought to go over that entry check list and be sure that you know where everything is that you need. If that's done, everything ought to be pretty straightforward from there on out. The time line is adequate, assuming that you have no malfunctions to contend with and assuming that everyone knows where his equipment is and that it's organized and ready to go. Power transfer to the LM went as advertised. There were no problems.

ROOSA My suit circuit integrity check, where I put on my helmet and gloves and run through the integrity check — I had my mind on

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(CONT'D)

going right by the decal or the checklist, whichever one I happened to be using; making sure I didn't miss any steps. I started off using the decal, and the integrity check was not looking right so I got out the systems checklist and proceeded step by step and it still didn't look right. The problem is where the flow is still on the other two hoses. Somewhere it may say to turn that off before you disconnect. Before you start the suit circuit integrity check, both those other two hoses have got to be off and it doesn't specifically call that out on the checklist. So, I was trying to pump up my suit circuit with flow going into the cabin from the other two hoses. So I followed the decal instructions, then the checklist instructions, and then I concluded that this wasn't going right. Then I started things that could affect it and, sure enough, the suit flow was off. So, that probably held me up 5 minutes or so and I ended up with the cabin close around 6. Once I turned those off the integrity check proceeded with no problems at all.

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8.0 LUNAR MODULE CHECKOUT THROUGH SEPARATION

SHEPARD We will put our comments on the LM and CSM together at this point. We've covered IVT. In the interest of speeding up this debriefing, we went right down the checklist like the other people did. Ed and I both had a copy of the activation checklist. Until we come to some anomalies, just assume that we don't want to make any comments. The checklist was adequate. The primary EVAP control has been documented.

ROOSA We ran through the checklist enough times that I felt his checklist and mine were coupled together quite well. They really flowed well. We had no trouble at all. It was just like a SIM without any malfunctions.

SHEPARD That's right. We didn't have any problems. We had gone through docking SIMs a number of times using CMS and LMS together at the Cape. We felt real solid with that.

There seemed to be moisture on the windows of the LM. At 102:32, we turned on the LM window heaters on both sides to get the moisture out. The moisture was left over from Florida as far as I can tell. I think the moisture came from the previous IVT and the water vapor that we left in there from

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SHEPARD (CONT'D) our launch. It wasn't anything serious. We turned the window heaters on, and it's obvious when the windows get too hot. You can feel the heat on your face so you turn the window heaters off. It's as simple as that. It's like defrosting the windshield of your car. No problems with the IMU coarse align and all the other mental arithmetic associated with it.

MITCHELL Down to the ascent battery activation checkout, we had absolutely nothing. The ascent batteries checked out just exactly like they had done in TLC with battery 5 reading 0.3 volt low. It was absolutely stable with no change.

We have one comment on RCS pressurization. I believe a main shut-off valve, some way or another, was cycled closed. It seemed that when we cycled a main SOV open, it clicked as though the valve had actually cycled. We saw no anomalies on the talk back at all. We did hear what appeared to be the cycling of the valve when we moved that.

QUERY Do you feel the landing gear deploy?

ROOSA You called us and I heard the shutter.

SHEPARD We decided ahead of time to try to transmit when we were going to use the repress valve in the LM because that makes

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SHEPARD quite a bit of racket. Also, Stu was called when the landing
(CONT'D) gear was going to deploy so that we wouldn't be upset.

ROOSA I went to my window then. I looked in the tunnel at that
time, so I didn't see anything. But, I could feel it shutter.

MITCHELL The temperatures on the quads, when we started RCS pressuriza-
tion were 150, 140, 140, 150 in that order.

SHEPARD We have numbers for the temperatures, pressures, and mani-
folds, et cetera, if anyone needs them. It's all written
down.

MITCHELL RCS checkout went right by the book.

SHEPARD It was as advertised all the way through.

MITCHELL Pads came up in good form. We came up even a little better,
earlier than the time line shows. All went smoothly. I
might add that, in SIM, we generally ended up with excess time
in the activation portion but due to our desire to check every
item and mark it off the checklist, we were exceptionally
slow and thorough so there was not an excess of time in that
time line. It was comfortable and it gave you plenty of time
to do it slowly, thoroughly, and meticulously without a great

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MITCHELL deal of excess pad. In SIMs, we always had at least an
(CONT'D) extra 45 minutes.

We did start having trouble with our steerable S-band antenna at this point. This is the only anomaly that we had and we might as well discuss it at this point.

The symptoms that we saw onboard were an oscillation of the S-band steerable antenna and an occasional popping of the circuit breaker without the steerable antenna hitting the stops. Now, I'm aware that it pops the circuit breaker when it hit the stops. Sometimes it didn't do that when, for one reason or another, we lost the signal from the ground. As soon as it stopped, or hit the circuit breaker, or when the S-band noise came on, I'd catch it. But there were two or three times during the mission in which that circuit breaker popped and the needles were still showing on scale. At least the indication to me was that the antenna had not gone into the stops.

During this activation, we had one needle, the pitch needle, that was not indicating. The antenna apparently was moving and operating properly, but the pitch needle would not indicate. When I first saw it, the needle was hard over on the plus stop. I thought that I had slewed into the stop. I

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MITCHELL
(CONT'D)

immediately went to SLEW and tried to pull it out. The needle was not moving. Then, in coordination with the ground we got the antenna locked on and ignored the pitch needle. Some time after that, we observed the needle was functioning again. From that point on, our problems seemed to be spurious and random. I'm unable to coordinate as to when the ground dropped an uplink signal which would cause us to break lock and slew into the stops. My indications on board were spurious and random driving into the stop, popping of circuit breakers, and sometimes popping of circuit breakers without driving into the stops.

The S-band antenna was exceedingly noisy, and I'm aware that that's a noisy antenna. It was noisier than I had heard in spacecraft checkout. It seemed to dither a great deal. The sound was like gears about to come apart when it was dithering.

SHEPARD Yes. We verified that only after we were on the lunar surface, and we had a look at it in the shadow of the LM. There was a lot of noise.

MITCHELL But it turns out, it's the same noise we heard on the ground. We could see it dithering in the shadows. I can't think of anything more to say about that. Our indications were very spurious and random on board.

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SHEPARD As a result of the S-band problem, we were a little bit behind the time line. I called up P47, and we weren't quite in the AGS so we had to ask Stu to hold off for a few seconds prior to undocking. But it was only a matter of 5 or 10 seconds, I guess.

MITCHELL The AGS came up on 47.

ROOSA You said, "Give me about another 5 seconds." I waited 5, and I said, "Are you ready now?" and you said yes.

MITCHELL The ground wanted us to recycle the steerable antenna once more and we were close to SEP. I requested we stay on OMNI because I didn't have time to mess with it at this particular time.

ROOSA After you get the LM out on the end of the probe, you're sitting there in SCS control, low rate, and min dead band. The checklist doesn't call for LIMIT CYCLE ON. I think it probably should, because during the SIMS, once with the LM on the end of the probe, I got a little perturbation and started this constant roll fire. When you have all eight roll jets enabled under that SCS min load configuration, you're going to bang in roll if you are ever perturbed. I asked Phil Schaefer if anybody was concerned about this,

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ROOSA
(CONT'D)

and they weren't. I never did like the idea of pulses and roll jets with the LM on. During the actual separation, this pulsing started before I ever extended the probe. I got a little perturbation of something, maybe the S-band antenna on the LM, so I started this oscillating in roll before I ever extended. I turned off four of my roll jets, and this did away with the problem. I originally proposed we sep with four roll jets off. What you're doing is taking away either a Y or Z translation. If you need it, you could bring it back on. I turned off four of the roll jets. That solved my problem. The LIMIT CYCLE ON may solve the problem, too. I never looked at that. Then I get the EXTEND switch, and the probe came out in a hurry. It went right to the end. I think it had at least two rebounds. I don't know if we had the third one or not. Were you counting them over there?

SHEPARD Just a couple was all.

ROOSA Then it damped very fast and was steady. The rest of it went per the checklist. I held the switch and backed off. It looked like it went real smooth. I don't think I perturbed the LM at all.

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SHEPARD There was no readout at all in P47, so we didn't integrate any DELTA-V at all during that separation. It was smooth.

ROOSA On docking and separation photography, I had the DAC running, and I shot 10 frames with the Hasselblad. As you moved on out and pitched over, you turned on the tracker light. It worked like a charm. Then you turned it off and that was the last I saw of you for a couple of days.

MITCHELL We went right by the book on LM photography with the Hasselblad and the 16 mm.

We had a little conflict at one point. Remember, Stu, CMC 3 and SCS wide dead band?

ROOSA Yes, I think that's your terminology.

MITCHELL It's probably a semantics problem, but nevertheless, it caused you to stop and think.

MITCHELL For RCS checkout, our checklist called for wide dead band attitude hold and you said, "Okay, I'm CMC free." I said, "No, we need attitude hold wide dead band." You said, "Mine says CMC free. I'll give you SCS wide dead band." I said, "Great."

ROOSA My checklist just says free for the RCS hotfire.

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[REDACTED]

SHEPARD It ought to be.

MITCHELL That's right.

ROOSA You shouldn't even see anything for the cold-fire check.

MITCHELL That's probably right, except my checklist says verify.

ROOSA That is an area of confusion, because we sat there in a dead band. We were in 5-degree dead band.

MITCHELL That should be quite adequate for what we wanted to do.

ROOSA Yes, 5-degree dead band is in the DAP and that's what we were sitting in. Then when you said to verify for the RCS checkout - -

MITCHELL Verify high bit rate with MSFN and CSM in wide dead band, at attitude hold. If you're sitting there in it, there's really not much point in saying anything for a cold-fire check. You've attitude control, anyhow.

ROOSA Yes.

MITCHELL We probably ought to take that out and delete any reference to it.

ROOSA Yes, the first thing I get on an RCS checkout is hot fire.

[REDACTED]

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MITCHELL I agree.

ROOSA That's right. We did talk about that.

SHEPARD So what we're saying is, on LM activation checklist page 2-23, scratch paragraph 1, verify. Well, you still want to verify.

MITCHELL You want to verify high bit rate, but you don't need to say anything about attitude hold because you're in attitude hold anyhow, and you're doing cold firing. So, it doesn't make any difference. It is just an added area of confusion.

SHEPARD Just verify high bit rate and then scratch the rest.

MITCHELL Yes.

SHEPARD After undocking I decided I was going to try to fly pulse as much as I could to save gas - everything else being equal in the controls systems, and of course it was. We had no control system problems, so most of the time I was flying pulse. I had no problem in handling the LM in PGNS pulse. It handles real well that way, particularly with the heavy separation weight. Changes in rate and attitude can be very discrete and precise. So, undocking, formation flying, and tracking during the SEP were no problem at all.

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ROOSA I didn't do any formation flying. I just left you; and I looked over and took pictures. At that point, I started my maneuver to the low-altitude landmark-tracking mode. You were on your way.

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9.0 PDI THROUGH TOUCHDOWN

SHEPARD Okay. There were no problems with AGS initialization and no problems with the DPS throttle check.

MITCHELL The camera setting in the LM time line book, right after AGS initialization on page 1, had a camera setting of 2.8 on the Hasselblad. It seems strange now, but at the time, we didn't think there was a 2.8 and I don't think there is. The lowest indicated setting on that ring was f/5.6, and we marked that in here. We ought to check that out.

SHEPARD Yes, we didn't know where the f/2.8 came from. That's why we circled that one.

On the first approach to the landing site, we had inertial attitude of 325 indicated. I flew to that. The flight plan indicated 325, and I went to that attitude. But, it didn't give us quite enough of a look at the approaching horizon. I made a comment here that we use 335 ORB rate attitude as being a little bit better during the landing phase. Even with that attitude, I was unable to pick out Cone Crater and the landing site on the first pass. The LM rendezvous radar checkout, in comparison with the VHF ranging on the command module, went just about as advertised. On our first P52,

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(CONT'D)

we decided we were going to run those two at the same time. We eventually worked it out with the CDR on the AOT and the LMP on the DSKY. Once we got into attitude and shifted into pulse, I would take over the job of pulsing on the star and marking. I think it worked out pretty well. We had a nominal 5 difference that I was pleased with. We had four on the very first one, with torquing angles of all less than 0.1 degree. I felt very good about that first P52. This is where you went to secondary transponder.

MITCHELL Yes.

SHEPARD You want to comment on that at this time?

MITCHELL We went to secondary transponder on ground call. They were trying to stabilize the steerable to see if we could get it to maintain lock a little better. I don't recall the result of that except at that particular time I thought that going to secondary seemed to stabilize the operation of the steerable. Subsequently, we had more problems with it.

SHEPARD At 105:30, right after the first P52, we went into an LPD CAL. This was primarily for the ground people and also to give us confidence in the LPD. It's not hard to do once you've finished the P52. You're in that mode, and in calling

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SHEPARD
(CONT'D)

up the LPD in P52 is no problem. We went right on through that and showed that we had a zero error in azimuth and only 1 degree error in elevation. So that made everybody feel good about the LPD.

MITCHELL

The AGS CAL on page 2 of the LM time line has a rough, rather elaborate procedure setup to hold the LM angles so that we don't get an error in the CDUs. It turns out, we really don't need those elaborate procedures. By calling up VERB 60, Al had the rates down under 0.02 deg/sec. We could have stayed in FREE after we nulled those rates and held it throughout the whole period of the AGS CAL. I would suggest simplifying procedures. That's the way to go, rather than waiting the 2 minutes and going back to attitude hold, stabilizing your rates, and then going back to FREE again. In this case, the rates were stable. They were just hanging right in there.

SHEPARD

We tracked Stu during the CIRC burn, here again, in pulse, with no problems. Now you've got the camera going and I guess Ed had seen some light out there.

MITCHELL

No we had not. We might comment that during the CIRC burn, we thought we would see the SPS light up. We did not. We were a little puzzled because we didn't. Just a few seconds later, he burst into sunlight, and he was right where he was supposed

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MITCHELL (CONT'D) to be. We could see him in sunlight, but we never did see the SPS light up. We haven't seen the film, so I don't know whether there's anything on the film or not.

SHEPARD We didn't see a thing out there at ignition. I know we were looking at the right place, because he was right at zero zero when he came out into view.

MITCHELL That's very surprising because we had the right attitude. We expected to see that engine light.

SHEPARD We've gone through SEP burn as far as the LM is concerned. Do you want to bring the CSM up to same spot, Stu?

ROOSA After I had you out of the window, I went right into my low altitude and landmark tracking on 14-1.

SHEPARD We didn't really get in your way that much.

ROOSA As I came in as before on the low altitude pass on H-3, the low-altitude landmark tracking was a lot easier than what I had envisioned. It was a "no sweat" operation. I'll bet a friendly 6-pack that this low-altitude is just as good as high-altitude tracking. I haven't heard any comments from FOD, but I think it's something that you could count on with

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ROOSA
(CONT'D)

certainty. It's not an unknown thing that you may or may not get. I had no trouble picking up the target.

From then on, I went right down the checklist until we got to the CIRC burn. I was quite surprised at the CIRC burn. I had a 2-ft/sec overburn. Every time in the simulator, you ended up 5 degrees off in attitude, and this is because it's such a short burn it kicks you off. You don't get back into the narrow dead band so you've drifted off a little in attitude. The burn itself was just like the simulator, with the exception of the overburn. Later on, they changed the CMC to alleviate this. I had to use some RCS. I was backed down a bit. I got it back to 1 ft/sec to satisfy the trim rule. Other than that, I had a lot of time getting ready for it. I just eased on into it, and it was a normal burn with the exception of the over-speed.

MITCHELL I have a comment we overlooked. It concerns coming up on the first pass around LOS time on page 2 of the LM time line book. Al and I had generally practiced P52 with both of us doing it. On this pass, we had the first indication of the abort problem. We also had the S-band giving us a little bit of trouble. About that time, the ground was trying to read up the PDI zero pad. It made the time of LOS a very

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(CONT'D)

great problem. We had to shift to the mode where Al did the P52 by himself, which is probably a good idea, anyhow, with just a little bit of help from the LMP. I was busy at that point and couldn't help him as much as we had practiced. I think the reason we hadn't practiced it was that the simulator doesn't give you a very good indication of when the terminator (when darkness) starts. We have probably cheated a little bit on time during simulations and started that P52 early, as we didn't really have a good indication when the terminator occurred. Consequently, we'd get started earlier and have more time than is actually available. I think it probably would be a good idea for subsequent crews to practice that darkness LOS time line in a more realistic fashion than we did.

ROOSA

Concerning the pads, it seemed as if I was always having comm troubles, and it was touch and go whether or not I was going to get all these pads.

MITCHELL

You were doing a P52 at that same time, weren't you?

ROOSA

Yes, but that's no problem for me. It was the comm. Finally, Fred just said that he was going to read them to you, and I could get mine later. As it turned out, the comm was in and

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[REDACTED]

ROOSA (CONT'D) out. It was in when I needed it, and I did get all the pads right. But it's fairly rushed if you're having comm troubles.

SHEPARD Was there an attitude problem there?

ROOSA I guess so. We'll have to wait until we talk to the MOCR troops to see what their ideas of the comm troubles are.

MITCHELL We were both having trouble at the same time.

ROOSA I spent 10 days in comm trouble, it seemed like. My downlink was so noisy that they turned it off as we approached PDI because it was interfering with your comm. So, comm was ragged throughout this whole period.

SHEPARD Well, after CIRC, we pressurized the DPS. That went as advertised with no problems. But at any rate, our checkout was right on the money with no problems there. Next we made a landing radar checkout. Then we had some pads.

MITCHELL I copied the pads. I had no problems there.

SHEPARD While he was doing that, I ran the LPD altitude check. I think it's good because it gets you in attitude tracking the surface and gives you more familiarity with what the surface looks like from that altitude. I don't know the accuracy of it. We came up with a value of 49 000 feet based upon

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(CONT'D)

procedures that we used in tracking it to a 50-degree yaw instead of the inertial, at an ORB rate attitude.

MITCHELL

Anyway, it puts you in a good position to observe the landing site. As far as the attitude was concerned, we were in the right attitude. We pitched over, and using our LM ground track chart, had no problem at all in spotting it this time. It looked like it was supposed to look. This is at the point where we were tapping the panel to get the ABORT button reset, or get the ABORT discrete reset. It didn't take a great deal of tapping. It seemed like just a few taps on the CDR side of the ABORT button — away from the ABORT STAGE side, on the left hand side of the button, kind of all around — seemed to reset it without too much work. So on each ground call, we tapped on it with the flashlight or pen, and it reset very nicely. As far as the abort problem is concerned, I'd like to make a comment here that we appreciate the ground holding off on that. I'm sure there was a lot of consternation on the ground, a lot of work going on, and we were aware of this because of our familiarity with local procedures.

We continued on with things that we had to do in the time line, and I thought the information passed up on that particular procedure for setting up that bit was excellent, as far

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(CONT'D)

[REDACTED]

we're concerned. It came up to us when the ground thought they had a solution — the best one they had at that particular point. We copied it down and were, I think, completely aware of the ramifications of it. So I thought that, procedurally, it was handled extremely well. We were able to press on to the next P52 COAS calibration, and the P63 initial logarithm test ECS checkout. There are no comments at this point. All the way through this thing, we're staying right on the time line, getting everything done that had to be done. So, it's obvious that we were able to press ahead with our time line while the ground was wrestling with the problem. So, I think that the way that was handled was extremely well done. It didn't bother us at all, although, we knew that everybody was working on it. We were able to press ahead with a minimum amount of concern. So that brings us right on down to PDI. I'll stop there and see if Stu's got any comment in that time period from CIRC to PDI.

ROOSA

I tracked 14-1 high altitude, and then I had COAS calibration. All that went well. All the spare time I had, I was working with the Hycon because we were coming up to the point to run through the procedures they passed up to me before. I guess I could tell things were getting tense down in the MOCR because Pete passed me up my own LTC photo pads here. I got

[REDACTED]

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(CONT'D)

the Hycon all set up; however, it still was clanking and banging so I elected not to shoot the LTC photo pad target 12. I thought maybe we would get the Hycon fixed. At this time, we really didn't have time to talk over the Hycon problem. My downlink was noisy, so they didn't want me saying much. I didn't know if we were going to fix it or not, and I didn't want to waste the film. So, I elected not to shoot target 12, but to go ahead and shoot the landing. I figured that was a one-time opportunity, so I shot it, even with the Hycon banging on me. Other comments I have that deal with the handheld photography, I'd rather cover later.

MITCHELL

Again, the procedures to get around the LGC abort never rushed us at any time because we practiced so many malfunctions during SIMs and in the IMS so many different ways, many of which were not in the ground rule limitations. In other words, we went ahead and practiced steps using more degraded modes than the mission rules would allow during an actual case. I think because of the combinations of the use of PGNS, AGS, ATT HOLD, and manual throttle on both sides of the cockpit, that the unusual procedures experienced in the actual flight PDI setup were not too unfamiliar. We felt comfortable about being able to cope with these unique setups.

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[REDACTED]

SHEPARD As far as I was concerned, I thought it was pretty good coming into PDI. Once we went through the final trim, got the inhibit in there, then I felt like we were home free. Of course, I was a little naive at that point about the landing radar. But I didn't really feel too uncomfortable at that point as far as the procedures were concerned. In reiteration, I thought the ground handling of that situation was excellent as far as we were concerned.

MITCHELL Yes, the procedures that came up and the understanding of the problem couldn't have been better. The words that came up were just the right words, and Al and I had no doubts about what we were supposed to do. Personally, we had a great deal of confidence that what you were passing up was going to work. So, we felt real good about going into PDI.

SHEPARD We didn't have much of a choice. It was either try that or give it up.

The manual throttle-up went just as advertised. We had auto-ignition. I guess there must have been some question about whether the ignition was auto or manual because Bruce called up one time. Apparently I didn't say that it was auto. But it was an autoignition.

[REDACTED]

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MITCHELL I was a little concerned because we were still having antenna problems at that point. We had this little discussion about whether to go down on OMNIs or not. The word was to go on OMNIs. I guess I felt a bit apprehensive about going on OMNIs with the problem we were having with the abort button. However, since there was no alternative, that was the way we had to go.

SHEPARD Well, as far as the procedure was concerned, I guess, again, we did it as it was handed up. It became obvious that things were working because, as soon as you set the guidance bit, it jumped right on down. It didn't go to a nominal angle at that particular point because it had been sitting essentially at the ignition attitude where it was apparent that guidance had initiated, and PGNS was happy with itself. So that give us a little more confidence that things were going along well. We had a NOUN 69 update of 2500 feet. Wasn't that about it?

MITCHELL It was 2800 feet, which we had practiced, and that went in with no strain.

SHEPARD Everything looked nominal up until we began to get concerned about why the landing radar wasn't getting a good data signal

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SHEPARD
(CONT'D)

into the computer, because the light stayed on on the DSKY. I'm sure that was being discussed on the ground as well as in the cockpit. The call, just like the landing radar breaker, obviously was an excellent call and that saved the day. So, we pressed on down after that. I can't say enough for the ground people on that particular call. The updates after we went to the VERB 57 converted immediately and made us feel pretty good. We watched them for a while, of course, but pressed ahead.

Normally, after throttle down, I had made a habit of switching to PGNS attitude hold to practice flying the error needles a little bit during that time period. It helped to get a feel for how the vehicle was going to handle in that mode later on. We did not do that this time because we were wrapped around the landing radar updating problem. However, I would still suggest it, I think. From my point of view, it gave me confidence being in the suited mode in the real world for the first time with the vehicle flying just about like it was supposed to. We came on down to P64, pitchover, and there it was. The landing area model was excellent in that respect. It was an excellent training tool, and there was no problem in recognizing immediately where we were. I think that was probably obvious from the in-flight voice comments. There

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was no question about where we were. If we hadn't been there, there might have been some question about where we were. But fortunately, we didn't have to make that kind of in-flight test. One LPD was used, I think one left, to designate to the point that I'd originally thought was the right one, slightly south of track. The LPD stayed good up until the point we got below 1000 feet. Then, it appeared as though it was going in a little bit short, right about in the middle of Triplet. So, I took over in PGNS, ATT hold ROD mode at that point. At that point, it became obvious to me that I didn't want to land south of track because the crater size was a little too large, I thought. So, I flew her on over using bank angle closer to the nominal original intended landing point where it looked a little smoother. We used the same techniques that we used in the LMS. Ed was inside the cockpit, mostly, giving me values of velocities, and I was outside the cockpit, mostly.

I think that was the part that looked very smooth, relatively smooth, and I landed. The control of the vehicle I thought was good. Here again, of course, I did practice with the LLTV as well as the LLRF, and in the LMS. I felt completely comfortable and completely in control of the vehicle all the time. The landing spot did turn out to be slightly on a slope.

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SHEPARD
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I don't think that was because of touchdown velocity, which must have been pretty low. We didn't have any stroking of the gear at all. The LM ended up in about a 7-degree right-wing-down attitude, which was exactly that of the slope of the hole in which we had landed. In retrospect, maybe a little higher H-dot would have been better. We'd have ended with the vehicle at a more level attitude. But, in any event, with the combinations of slope, 7 degrees was not bad.

For touchdown, we had the habit of waiting about 2 seconds after the lunar contact light came on before shutting the engine down. From the looks of things, we actually were on the ground and stopped before the engine shut off. It must have been a pretty light touchdown.

MITCHELL

From my point of view, after the last part of the descent, from the time the radar came in, things were fairly nominal. The AGS was updated on schedule. The camera was started on schedule and the checklist was followed completely the rest of the way down. It appeared to me that, when we pitched over, Cone Crater was right where it should have been. Al went ahead and made his redesignations. It appeared that the program was taking us to a point just short of North Triplet; at which point, Al took over and flew it on across

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(CONT'D)

North Triplet. From that point on, the landing was absolutely nominal, nothing different than we practiced during nominal SIMs.

SHEPARD

There's one thing I had intended to do, Ed, and I didn't do. Assuming everything else was normal, I was going to ask Ed to switch over and take a look at the landing radar and the cross pointers. But, that's one thing we just never did get done. It was going along fine, and I didn't think of it at that point. You didn't do it; so I don't have a real good feel for what the landing radar was doing to us during the final 200 feet of descent. But the data obviously can show, at least, what it was doing as far as the TM was concerned.

During the final approach, the visible landmarks were great. The zero phase was not a problem because we were approximately 14 degrees off the Sun angle. And at no time did I notice any problem at all with Zero Phase during the final approach. The elevation and distance estimation of landmarks is always a problem as far as I'm concerned. About the only thing I can recommend is that the CDR carry in his head the geometry of the landing site, the size of the craters, and the difference between the crater landmarks that are used. He should know exactly what those distances and dimensions are ahead of

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SHEPARD
(CONT'D)

[REDACTED]

time. That's one thing you've got to memorize because as far as I'm concerned, at least, even the L&A doesn't give you the feeling of looking at a crater which is unfamiliar to you and saying that I'm 5000 feet above the ground or 2000 feet above the ground. It's just something that you can't do — you can't relate it to your Earth-bound experience.

The utilization of the LPD was good. No problems there. Manual control has been covered. There were no problems hovering. I believe that we had less problem with dust than they've had before. I think it's because, as we comment later on, the surface of the general area in which we landed was less dusty, that is, exclusive of the dust around the rim of craters. The general area appeared to have less dust and we certainly had no problem with dust at touchdown. I referred to the cross pointers during the final stages of the descent at less than 100 feet, but only to assure myself that I had done the best I could as far as cross velocity was concerned. The dust was obvious, but you could also see the rocks through the dust. We had no problems here. I think we had a touchdown that was very light, just a little plop when we hit the ground.

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MITCHELL Yes. That's what we had practiced because of the dust problems. When we went into the ROD mode, we leveled out on ROD and kept it flying on over until I was sure we were to Trip-let and into that area where we wanted to land, then we started on down. I might add that looking at the film of the descent last night the dust problem appears a lot worse on the film than it appeared to me on the window. I thought I could see it a lot better.

SHEPARD You probably would, in any event, because the camera is only looking at one spot and you don't have the more general feeling that your eyeball gives you.

MITCHELL Right. But just looking out the window you can see the dust is no great problem at all.

SHEPARD Touchdown velocity was less than 3 ft/sec in all three axes, I would say. We were going slightly forward at approximately 2 ft/sec and 1 ft/sec to the right. The H-dot has got to be approximately 2 ft/sec.

MITCHELL I don't think we were moving that fast forward.

SHEPARD It was pretty slow. That was one thing that I'd wanted to do as a result of using the L&A and also looking at the Apollo 12 touchdown. I think it's better to have a slight

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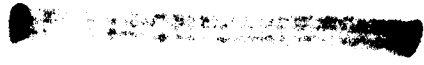
forward velocity because that way you're sure that if you have just crossed over a crater that you're continuing to move away from it. You can only see about 60 degrees down by getting all the way up and looking at the pad, and that's not straight down. So, I had decided ahead of time that I was going to have a slight forward velocity just to assure myself that I wasn't backing it into something. I think that's the way to go. Certainly, a forward velocity of 1 or 2 ft/sec is well within the envelope, the other parameters being equal. It's my personal recommendation to make the landing that way.

We had approximately five percent oxidizer, I believe.

MITCHELL The last callout we made was at six or seven percent I believe. I don't recall seeing it after that.

SHEPARD So, we touched down; went through the checklist; and did everything; dearmed; and there we were.

[REDACTED]



10.0 LUNAR SURFACE

SHEPARD The venting in the descent stage went as scheduled with no problems. We shut off the O_2 , the oxidizer, and the fuel vents as called out in the flight plan. We were in good shape on the time line as far as any aborts were concerned. The pads were there and, for a T_2 , we were all targeted and ready to go with a minute or so to spare had anything gone wrong. I think as far as the postlanding procedures were concerned, we got the T_2 stay so we called P00 and went into the Lunar Surface Checklist. We went through the PREP lists, page 1-1. There were no problems. We took the helmet, the gloves, and the restraints off so we were able to move around a little better. We recorded a NOUN 20 which showed that we were about 1-1/2 degrees off in yaw, about 1-1/2 degrees off in pitch, and 7 degrees off in roll. The first surface P57 went off on time. I found that it was actually easier to use the AOT on the surface than it had been in the LMS. As a matter of fact, that applies to the P52s as well. I had lot less problems in getting small NOUN 05s than I did in the simulator. So we can press right on through that baby. We didn't choose to start on the first P57. That was just the torquing the platform ...

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MITCHELL Yes. That was the gravity line.

SHEPARD ... to get the gravity line completed. We did go on into the next P57 after that with the stars.

MITCHELL I don't have much to say about it except, at the end of NOUN 05, we came up with plus 2 — 0.002-degree difference — so it was a good alinement.

SHEPARD We did our first T_3 stay and went into a powerdown which went as scheduled.

MITCHELL The only exception on our switch configuration at that point was that we were in secondary transponder having to accept that before PDI, and we remained on that. Before we started the P57 series, we observed that the butt of the radar antenna was in the field of view of the AOT. If I recall correctly, that should have been set down out of the way in orbit. It was not and it apparently drifted up from the time it had been set. It drifted up to where it was in the field of view of the telescope. We had to power up the antenna and drive it down out of the way of the telescope before proceeding with P57. We did not think this would happen. We figured it would stay in the park position.

SHEPARD That's parked during activation at 00033, I believe.

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MITCHELL Yes.

SHEPARD That had been done, and we were surprised to see it cutting into the field of view of the AOT in detent 2.

MITCHELL It seems funny that the friction locks didn't hold it in the proper orientation.

SHEPARD The powerdown was uneventful. Page 113 in the flight plan called for the first photography of the surface out both windows and a discussion of the surface features to some degree with Houston. That's all on the record. Now that went about as scheduled, and it was just a little give and take between us and Houston. We told them what we saw and we were asked a few questions at that time.

MITCHELL The only anomaly that I can think of was that during my first set of Hasselblad shots out the window, I inadvertently used the little "gouge" here from the Commander's window; and two of my camera settings were off, so I had to redo them. That wasn't even consequential.

SHEPARD We pressed on. We talked about geology. There have been some comments about the gravity measurements which Houston or the FOD people wanted to make on keeping the platform up, and if that would interfere with our ability to press on with the

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SHEPARD (CONT'D) photo surface time line. We tried it in the LMS a couple of times and felt that it did not interfere. In fact, it didn't because they were through with the platform and ready to power it down. It did not interfere with any of our activities at all. We still did not put helmets and gloves on. We were at a point where we could go ahead and power the PGNS down and turn off the platform with no problem at all. So that did not bother us. We ran the P22 radar track on the CM as scheduled — no problems.

MITCHELL We did note a couple of numbers on page 118 of the checklist. The preplan numbers that the antenna would drive to were 180 and 335. It did, in fact, drive to 185.06 and 331.03.

SHEPARD We went ahead to a powerdown configuration of circuit breakers and right on into the PREP. We didn't notice any problem with the drift of the platform after landing. Did you notice any AGS problems?

MITCHELL Everything was just fine after we had disposed of our landing radar problem. Everything was absolutely nominal.

SHEPARD We watched the steerable antenna for a while. We had no problems with the temperature of the cabin or with cooling. Inside the LM, during the low periods of activity, the liquid

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SHEPARD cooling garment has more than enough cooling for me. At times,
(CONT'D)

I disconnected my water hose from the suit, because I felt very cool and comfortable.

MITCHELL That was generally the case. I always felt a little bit warmer than Al or Stu, so I kept mine on more than either of them.

SHEPARD We pressed on into the pre-EVA. We'll start with egress. I said that we had no problem in recognizing where we were as far as the site location was concerned. There was some question whether it was plus or minus 50 feet from where we actually ended up. I'm sure that the photographs will be able to pinpoint that exactly later on. The general impressions that we had here we talked about on the comm with Houston. I might comment that we did actually land in kind of a low spot. I thought that we were looking ahead downrange to Doublet Crater and found that it was slightly above the eye-level elevation from the ascent stage while we were still in the ascent stage. I looked out the LPD and it looked like it was about 1 degree. I was taking the vehicle pitch into consideration and it was 1-1/2 degrees above our eye level. So we were a little bit below. The surface was certainly below the level of Doublet. The ground appeared to go up to

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the south, the north, and to the east. We were in a relatively low spot as far as the whole general landing area was concerned.

The lunar chart that we had of the landing area was adequate for us to verify our location. The white shadow contrast was about all we expected at low Sun angles. Obviously the contrast was greater, and that certainly is pointed out by the fact that it was the same as we expected it to be. Certainly it's advantageous to land in those low Sun angles. We had practiced at higher ones, and I don't think that a Sun angle of say 1 day later — 15 degrees higher — is prohibited. But it could be prohibited from the standpoint of visual acuity if it were combined with looking down-Sun. If you were coming in without the Sun displaced off the approach track and with higher Sun angles, you might have a problem, in earlier assessment of LPD corrections.

Jack said we were 14 degrees off and we had no problem with zero phase. Certainly any more than that is fine. Now, whether you can come up with any kind of a magic — I'm sure you can come up with a magic formula that says as long as you're outside of a cone of less than, I don't know, 6 or 7 degrees in elevation and azimuth with respect to zero phase, it's probably okay. That would be a ballpark guess. I think you'd probably want to look at the zero-phase photographs to

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figure out what kind of an angle you have to have in all directions to describe the cone (the combination of horizontal and vertical angles). You find that, outside of that cone, the eyeball's ability to discern features is good enough.

Concerning my impressions of shapes, colors, and shadings of near-lunar surface features, they're all easily recognizable. I think after you work with a few of the geologists that are involved in the flight experiment (which you probably ought to do during preflight geology) you have an idea of what kinds of things they like to hear and what kind of things that enable them to get a better mental picture of the general geological structure of the area. These are the kinds of things you are looking for and, certainly, they're easy to see there on the surface. You know that you're looking for textures and differences in elevation and ray patterns, and differences in rock sizes and rock populations and these kinds of things. They're all there, easy to see, and easy to recognize.


MITCHELL In looking out the window from the LM, I had a very definite impression of the relief. I think we stated several times that the relief was greater than we expected. However, I observed that when we got on the lunar surface, subsequent to that, that your observation of the relief changes with Sun \

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MITCHELL angle. The Sun wipes out — or seems to smooth out — a lot
(CONT'D)
of relief that you see at certain Sun angles and that you just
don't see at other Sun angles. Or maybe the visor distorts
it in some way. But sometimes you see a very good sized
crater, a depression ahead of you. You look at it at a
different angle and it's just gone. When you turn you head
a different way, you don't see it. So, perhaps there's a bit
of distortion in the visors. You're never quite sure whether
it's visor distortion or whether it's Sun angle or what it is
that causes you to see these things or not to see them at a
particular point in time.

We ought to make a comment on using these cards, at this
point. The way we had these cards set up, with rings in them,
and hooking them over the toggle switches on the handle is
absolutely unacceptable. We had to take some of the little
utility straps and tie them to those toggle switches because
in one-sixth g all it took was the slightest bump and they
fell off and were on the floor. So we need to improve that
situation a bit.

SHEPARD Well, I don't see any comments here on EVA-1 PREP. There were
no anomalies.



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MITCHELL None, except for comm. I guess we'll have to do some work with the systems people before that's finally resolved. At one point, we were supposed to cycle the audio circuit breaker open and close. Although I can't remember that perfectly, I think that was done, because as we did our checks A and B, we still had comm with the ground as we were supposed to have. Now I don't believe we would have had that if the circuit breaker had been open. We'll just have to find out if it is possible. I do know that when we could not get comm on AR, I disconnected my LM PLSS and went back to LM comm and we established comm. That's when we switched to relay through the Commander's audio panel. We did not have AR at that point. And I did definitely discover at that point that in going back to the LM comm, I had reset the circuit breaker. Then we turned to PLSS comm and, at that point, I know that I pulled the circuit breaker and did not reset it as I was supposed to have. And that was what kept us from getting comm relayed through the Commander's panel. But I cannot state for sure whether or not the circuit breaker had been properly cycled the first time we tried AR. That I just don't know.

SHEPARD Well, I think you ought to make the comment here that when we get to that point in the checklist, that rather than make it one single step, where it states "LMP: Connect audio

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SHEPARD (CONT'D) breaker open and close," that we should make it three steps: open the breaker, disconnect, then reclose the breaker. Anyway, we worked ourselves out of that problem and eventually got comm, although we did relay through the CDR's panel instead of using the LMP's panel for the relay position as the checklist called for.

MITCHELL We stayed in the Commander's relay only because there wasn't time or there wasn't any point in going back and checking to see if we really had a problem. And since we had good comm through the Commander's relay there was no point in changing it.

SHEPARD Right up to the time we started out the hatch, that was the only problem we had. I was unable to reach, without a great deal of difficulty, the PLSS feedwater lever. It's because of the location of the PLSS, behind the suit, where I couldn't get my hand in there when the suit was pressurized. We had done some last-minute adjustments to my straps to allow a better aiming of the camera bracket in the front of the RCU and, in fact, that's what did it. So, if I'd struggle with it, I think I could have made it, if I'd had to on my own. It turned out to be easier for Ed to do it for me, so we proceeded, PLSS feedwater on and off on both occasions using that technique. I'm not sure why it was different. I guess in

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SHEPARD (CONT'D) rechecking the PLSS mounting after we had changed the straps, we used a one-sixth-g rig in the suit room. I guess this assumption wasn't quite right because I didn't have any problem reaching it in the suit room but I did in the actual suit. Okay, so we finished and got outside.

I think the EVA PREP and POST cue cards are good because we can hang them up. It's right in the center of the panel and you both can see it and refer to it and follow right on down the list. We have these things blocked off in various ways to make it easier to follow. We had done a lot of EVA PREP and POST and suited operation in training using the mockup at the Cape. Incidentally, the fidelity of that mockup was good. Millican has done a good job on that. He was there with us during all those exercises and they paid off. We felt right at home — well prepared for all those operations. The only thing that got us behind the time line was that comm problem. I don't think we had any other problems at all.

MITCHELL The only comment I would make regarding the time immediately before egress was on the suit integrity check. My suit loop drop was higher than we expected. This showed up later in what the ground assumed to be a higher leak rate. When we checked the suit before ingress on launch day, it was tight,

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MITCHELL there was no draw whatsoever. And I had close to a
(CONT'D) 2-1/2-pound drop in the 1 minute check.

SHEPARD You mean 0.2.

MITCHELL Yes, 0.25 drop before we egressed, which was surprising and
inexplicable. It was more than I expected. But, because it
was within limits, we didn't say anything.

SHEPARD Specification is 0.3 there; 0.3 psig in 1 minute and he was
just below specification. No problems in getting out the
hatch as far as I was concerned. Just the way we had planned
and practiced before. We had no need to deploy the EVA whip
antennas inside the spacecraft. As we had practiced, Ed
deployed mine as I was going out the door and I deployed his
later, after he had come out on the surface. That worked
out real well.

MITCHELL I disliked deploying those antennas inside. I think it's
because we broke off a couple in practice. I'm still against
deploying those antennas inside, except as we did it with Al.
He was on the way out and was obviously clear when I deployed
it. This procedure leaves the LMP with his antenna folded
until he gets outside. I suggest we do it that way because
I would hate to see you snap off an antenna on the plus-Z 27
bulkhead on the first EVA. I think it's highly probable.



[REDACTED]

SHEPARD No problems with the stability and balance. We had done this on two separate flights on the one-sixth-g airplane and practiced getting it out on that. We didn't do any training in the water tank, but felt that the airplane training was adequate for the occasion.

The jettison bag was passed out and I threw it down on the ground; no problem. The equipment strap deployed, the MESA pulled, and everything went as we had expected it. Of course, we had practiced deploying the MESA with the flight hardware. We knew pretty much what to expect with the descent stage, as a result of the C^2F^2 . We had done that at the Cape with the actual vehicle. So that was not a surprise; no problem there. We got down the ladder fine, down on the ground fine, and had no mobility or stability problems to speak of. It takes a little while to get adjusted to it, but it's no more than just a couple of minutes before you're off and running. I had no problem adjusting the height of the MESA at all. In one-sixth g, it comes up and down very easily. I was surprised that the thermal blankets were glued on so tightly. I guess in training we use them so much, they come off a lot easier. The first surprise I had was when I tried to remove the thermal blanket for the MET. I grabbed the ring to pull it off and the ring came out and the blanket was still on there. So I

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(CONT'D)

had to get it down with my hands. The difference is that that clear tape used to tape that stuff on makes it that much tougher. It came off all right, but we had to use a little bit more strength than I had expected to have to use to get it off. The pins on the MET pulled fine. The insulation blanket on the bottom of the MET, between the MET and the MESA, actually held it up there. So I had to pull it off when the pins were released. The one-sixth-g weight wasn't enough to make it fall down. So anyway we finally got it off. We put it in the plus-Y footpad. Here again, comments on mobility. This business of having to adapt fairly slowly is a familiarization process. Do it very slowly. Other fellows have made comments about its being different as far as controlled c.g. is concerned. However, if you fly in a one-sixth-g airplane and then go through a period of zero g, you get to the point where you're not so heavy handed with the maneuvers. I really felt right at home almost immediately as we got on the surface. Balance was good and getting control was good. I did not fall down at any time during either EVA. I got down on my knee a couple of times to pick up some things but I got right back up again. Never, at any time, did I have any trouble with falling down and balance. We had the same problems everyone else did with the cables,

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SHEPARD (CONT'D) of course. You have to watch them. We pulled the television camera over them one time. That's just a matter of the cables being there and sooner or later you're going to run into them.

MITCHELL I agree completely with Al on the ease of mobility. The one-sixth-g training was all we really needed. There was no big problem with overcontrol, stability, or anything.

SHEPARD Well, first of all the TV tripod came off, and the camera came off; no problem at all. It was mounted in place as we planned it. And the S-band antenna came off the LM as advertised and the deployment went fine up to the point where the dish holddowns were released. When the umbrella came out, it hung up on the top. The netting on the antenna hung on the top of one of the umbrella ribs and it did not deploy fully. I lifted it up, tilted it over, and Ed reached up and deployed it. He released the little netting cufflink from the rib of the S-band antenna umbrella and it went right on up after that. We had no problem with alinement. We close alined it using the eyeball, looking up at the Earth. We then made the fine alinement using the prism sighting device; it worked okay. We alined it once and that was it. We stayed within the time line and had no problems here with the equipment transfer bag. That, by the way, was a lot easier

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SHEPARD (CONT'D) to do in one-sixth g than in one g. The principle is fine. We had no problem alining the equipment up and down in the planned manner. You might want to comment here about going back in.

MITCHELL Yes. Let me come up to that point. There are a couple of comments I want to make concerning when I got out of the LM. There were no particular problems. The comment here concerns the 3-foot-diameter crater, 8 to 10 inches deep, between the MESA and the plus-Z footpad which was somewhat of an annoyance. It placed things on an elevation and sometimes you were on a slope. The reason I mention it is because the TV cable which comes down on the right side of the MESA, instead of laying flat on the ground, came down over this crater and caused me to tangle up in it several more times than I probably would have otherwise. Getting the CSRC out was no problem. I did overfill that bag and it caused subsequent problems in getting it closed up properly. The top of the bag did crack, apparently because of the cold or the vacuum effects, so that the contingency sample was leaking. It caused us to handle it a bit differently when we subsequently stowed it. We stowed it in one of the rock bags, instead of being able to stow it by itself. It was leaking very badly. The SWC deployed without any problems at all. The LRRR came off without any problems

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MITCHELL at all. Getting back into the LM, the ingress, was absolutely
(CONT'D) no problem. I was able to bounce up on the ladder, quickly
move on up, ingress, switch the antenna, and the only thing
I might comment on is something we already know but still
worth mentioning. Going in and out of that hatch you have
to remember to keep your posterior up and your head down in
order not to rub the PLSS against that upper hatch seal. It
would sure be bad to damage it. You have to really concentrate
when entering in the horizontal attitude, so that you don't
drag the upper seal.

SHEPARD This technique is the same technique used in the one-sixth-g
airplane using the hatch mockup to position your body. It
isn't complete, but it's excellent training.

MITCHELL You're right; in the one-sixth-g airplane, you normally don't
practice getting completely in because of the time limitation.

WARD A question about where the S-band antenna was deployed.

MITCHELL The S-band antenna was deployed too far out. The confined
area used in the training building never allowed us to deploy
that antenna to the full length of the cable. So we really
didn't know how far out to carry it. Consequently, Al carried
it to where he thought it should be, and it was just too far.

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SHEPARD There were no problems with the flag. It came out all right.

MITCHELL One comment on the flag. Because of the placement of the holes in the training building, we were fairly well constrained in where the flag was set up. We had already agreed that we were going to set it on the opposite side of the LM in view of the TV camera, in real time. Because we didn't have a hole on that side of the LM mockup in the training building to practice it there, it took a few moments to select a site in view of the camera and also in line of sight of the 16-mm camera. I think that's what caused our delay in getting the flag set up. In my opinion, the site we selected was a little too close to the MESA because at times it got in the way of the rest of our work.

SHEPARD Well, I would make the general comment here that you try to set up a time line for EVAs that would leave extra time. The last two things that we mentioned, the positioning of the flag and getting the antenna out too far, are the little things that come up during the time line. If you plan an EVA that you can do in one g, and after you've done it numerous times in the mockup, if you aren't able to get ahead of the time line, then I think you've got problems.

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[REDACTED]

MITCHELL Definitely.

SHEPARD If you have a time line you can go through after practicing in one g, and you don't have any built-in pad, then I think when you get on the surface, small, unexpected things such as the blankets being a little hard to pull off, fittings being a little bit harder to use because they're newer, positioning the antenna correctly the first time; these little things should be allowed for.

If you can build in a 25- to 30-percent pad in your training cycle, then I think that's somewhere in the ballpark. It's what you need to take care of these little odds and ends that always crop up.

MITCHELL To show how our planning worked out in relation to real time, consistently near the end of our training, we were getting ahead of our time line by 25 to 30 minutes by the end of the ALSEP deployment. We felt that would be adequate to take care of the extra time that we would use on the surface in being more careful, and to allow for problems. As it turned out, it really wasn't quite enough. We ran longer in real time. Of course, there's one factor you can't take into consideration. That is the fact that you're just a bit more careful with the actual flight equipment — in the actual

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(CONT'D)

case, you want to be sure you do it exactly right, so this just takes a little extra time. That's something difficult to factor in there. So I think the fact that you've got a 25- to 30-percent build-in pad there, and you don't have to tell people about it because there's no way to explain to them what you need this for unless you've actually been there and done it yourself or you have talked to people that have. That's the kind of thing you keep to yourself, but every followon crew should be appraised of it.

I did the inspection of the LM and the photography of the LM while Ed was doing the TV pan. There was nothing unusual there. We've documented the fact photographically, the way it looks, the erosion area, and the radial pattern areas of the exhaust were immediately obvious in the vicinity of the LM. One of the things that everyone notices when they look at it is that you can tell immediately it's a man-made pattern because the lines radiate from the bottom of the LM. You're able to determine right away that it's not any kind of a local geological feature. Three pans were shot per the time line. We'll cover the description of the area in the geology debriefing.

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MITCHELL
(CONT'D)

The position for best rest; I don't think you have to worry about that. If you do not strain against the suit, the suit's going to put you in a position (slightly bent forward at the waist to keep from toppling over), which is the best rest position. If you just relax, the suit will put you in the best rest position. It's a natural position; the position of the Neanderthal man, slightly bent forward with arms hanging down.

SHEPARD

The MET deployed as advertised. We had no problems with unfolding it — no problems with the wheels, the legs, the handles, trays, springs, or anything. It just snapped right out. At that point, we moved on around back to the scientific equipment bay and took out the ALSEP packages. Did you see the deployment of the MET on television? It couldn't be seen very well. Probably too much reflection from the LM. In the future, maybe we could go ahead and plan on that. If you want to watch some activity right at the MESA, the TV could be stopped down, so you can see that, or see the activity in the suits. Then, when you want to reflect general, distant activity, you open up to a different setting. I remember saying to myself, "We're spending too much time with the television camera." Maybe I said it on the air. We were

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SHEPARD spending too much time twirling those settings with that
(CONT'D) and were getting behind our time line.

Ed worked the doors on the equipment bay and they came open; didn't hang up or anything. We didn't have any surprise there. The packages just came out on the booms. Everything went along well and pretty much on schedule. I don't think we were too far off the time line as far as that particular aspect of it was concerned.

MITCHELL I think it's significant to point out that in training, we were generally 5 to 10 minutes ahead at this point.

SHEPARD I have the same general comment as previously made that if you're not ahead in training, then you're going to have problems. In training, we generally were 20 minutes ahead on the ALSEP deployment.

MITCHELL There's hardly anything to comment on about the deployment of the ALSEP and on the fueling of the cask, except that due to the cratering of the area right around the LM, we had less area to work in. So we were working the barballs and the two pallets in very close to the LM as opposed to having a little bit of walking room. There was a crater right behind,

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MITCHELL there were a couple of craters right behind the LM and on
(CONT'D) either side of us. They constrained operations somewhat.

SHEPARD We didn't have any problems in loading the MET.

MITCHELL No, except in tangling up the cables as we both did.

SHEPARD There is not much you can do with those cables except just try to stay clear of them. You might dig a trench and bury them if you thought it was worth the time, and it's about the only thing I can think of. Bury them at least in the area of high activity right around the MESA.

MITCHELL Or move them closer to the LM or out to the side so that they're not right in your walking area. I think we can make a comment right here that cable-set on all the cables was a problem. Just about every cable we pulled out had some set in it that made it curl or kink, and it would not lie flat.

On loading up the MET, as we suspected it might be, the spring clips on the camera mounts and the magazine stowage areas, in order to have sufficient strength to hold the equipment on, also had sufficient tension in it to lift the whole MET right off the surface when a piece of equipment was taken off. I'm not quite sure how you get around that problem.

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SHEPARD We didn't have any cameras bounce off, though.

MITCHELL No. We didn't. They had the proper strength to hold the equipment and hold it well.

SHEPARD On the traverse up to the ALSEP site, I was pulling the MET with the LRRR and Ed had the dumbbell package. We encountered no surprises during the traverse with the equipment. Although we didn't start off at high speed with the MET, I could tell from the configurations of the handles when the MET was tending to tip from one side to the other. It does it very slowly so you can, by twisting your hand, counter that tendency to go over. I think you thought that the dumbbells were a little heavy.

MITCHELL Yes. They were heavier than I expected. Let me explain it this way. In carrying the ALSEP package, the carrying bar flexed and as I bounced along, it was just flexing up and down. The dumbbells were vibrating out on the end and it made it kind of a wriggling mass. It was somewhat hard to handle. Carrying it out like this, my hands got very tired with all this motion going on and flexing of cables. I eventually ended up carrying it across my arms. That worked pretty well, but it was still considerably heavier than I anticipated since the one-sixth g lightweight mockup didn't

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MITCHELL really respond that way. It was much easier to handle.
(CONT'D) Furthermore, in one-g training, we never carried it that far. We only carried it a few feet. In this case, we were carrying it a couple of hundred yards. It was heavier and more difficult to handle than I thought.

SHEPARD I'd like to make a recommendation about the training at the Cape. We would get to the point in the EVA where we were to walk out to the ALSEP site. We would walk to the door, get in the truck, and ride out. Somebody else would drag the MET out for us. At least once we ought to go ahead and carry the thing out there to give a feel for it.

MITCHELL I have the comment that although my suit did exceptionally well, far better than the training suit ever did, it was still stiffer and took more effort to just hustle it around than the training suit did, which was well broken in. I encountered a little bit of a problem with bending over, which I had not encountered in one-g, and I think this is in proportion to the forces between the one-sixth g and the stiffness of the suit as compared with the well-worked-in suit in one-g. I found that I could not bend down to the MET level. I could not just bring my body forward like I could in the training suit and get down to the MET. I had to bend my knees or get

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MITCHELL down on a knee to reach things low on the MET such as the
(CONT'D) weigh bags down on the side, or the camera retaining clips
on the MET. It was more difficult for me to bend down for
them.

SHEPARD I don't know whether it was unique to Ed's suit or not,
because I didn't have that problem.

MITCHELL I was very surprised by that. I don't know what really
caused it either.

SHEPARD Okay, we had selected an ALSEP site.

MITCHELL It's about where the map shows it.

SHEPARD In looking at the map again, it looks to me as if we were
just about where we thought we would be on that one. Perhaps,
we were 60 feet north of where it shows on the EVA-1 map but
certainly no farther away from the planned deployment location
on the map. It may be a little bit more in line with the
Subdoublet.

Yes, it may be, because we tried to get it up on a spot that
has a little elevation.

MITCHELL The real problem we had in trying to psych out the right spot
was in trying to find an area flat enough for the central

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(CONT'D)

station and still have a reasonably straight line for me to lay the thumper out, with the constraints of not getting the north ridge with the mortar pack and being able not to cross the crater and not cross a ridge, and going south with the geophone wire. So with the undulations and the roughness of that terrain it was a little bit difficult to find a proper site.

SHEPARD For future crew information, I think you ought to have all these requirements for ALSEP equipment location planned so that a few minutes should be allotted in the time line to look around and get all the parameters of placement satisfied. Which, of course, we didn't do. We just walked up to the sandpile and said this is it, and then off we went. I'm not talking about east versus west or north versus south. I'm just talking about how to fit it in the local terrain.

Off we went on the unloading. We have documented that photographically. I haven't seen the film, but I suspect that it will show we immediately had a problem. The problem was a result of the dust on the thing called the subpallet. I don't know exactly when it happened. Of course, the packages have been lifted and set down a couple of different times, as part of the actual deployment. We came to the point where it was

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necessary to remove this subpallet. We found that that came off all right, but when we attempted to take the SIDE off, we had a problem. The SIDE is actually held down by two Boyd bolts — four Boyd bolts total but two on one side which was near the side of the package that had been set into the surface. There was a lot of dust on one Boyd bolt — the one that is visible — which I was able to knock off and get the tool in there to get that one unlatched. But the one that's blind — the one to which the tool has to pass into a channel to get — was just very difficult to get into. I don't know just what they can do except maybe not put that one on — if they can satisfy the vibration requirements of launch and hold that baby down with only three bolts, all of which are visible and all of which can be cleaned out by just picking the package up and knocking it a little bit. You can see the dust going out of that thing. But the one that's in the blind gave us a lot of problems. We finally got it out, but I'm not sure whether it was more luck than anything else. There wasn't any skill involved.

MITCHELL We just turned it over because it was a two-man operation. We turned it over, beat the dust out of it, and held it in the light so Al could see it; and finally he was able to wiggle it.

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SHEPARD Well, which you couldn't really do.

MITCHELL UHT down into it and release it. Otherwise, we would have been screwed on that one. We wouldn't have been able to do a thing with it.

SHEPARD The easiest thing to do is just not tie that bolt down. If you can get away with three bolts and meet the strength requirements, just let it go that way. Did you have any problems in there? You were setting up the RTG there.

MITCHELL No problems with the power plant at that point.

SHEPARD No problems in deploying the little stool for the seismograph. You deployed the thumper-geophone; any problems there?

MITCHELL No problems at all.

SHEPARD The central station was leveled fairly easily and erected with the SIDE curtains deployed. That went along with no problem.

MITCHELL To back up just a minute, the only problem we had with the deployment of the thumper was moving it from the station. This was because of the geometry of the craters. We had to park the MET a bit farther away than nominal, and I had to pull out considerably past the first geophone to have a place just to set that spool up against the MET. It was no great

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trick except it was due south — the MET was due south of the central station — and we would like to get the anchor into the geophone line almost due west so that we would have plenty of west clearance from the central station. It took a little bit of time after that to reel off some more cable from the geophone line and to pull that cable back to the west of the central station to get adequate clearance. It's just another one of these little things that took time that we hadn't planned on.

SHEPARD

As for leveling and erection of the antenna for the central station, we may as well cover it all at once. I had no problem doing it. Apparently, everything was going along fine during the first EVA, but we had to go back out again and redo that later on. The only thing I can think of is that somehow it must have gotten jostled, changed its position, and wasn't noticed because the numerical settings were still the same as they had been set originally. I could notice that there had been very little change. The only thing to suggest is maybe we ought to have a GO to leave the area with everybody satisfied with the alinement of that thing; because if it had been jostled, certainly it would have shown up before we left the area. That would have saved a trip back. They gave me a couple of new numbers which differed slightly. It says

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SHEPARD (CONT'D) confirm the data here, which obviously you do, 10 minutes after you get the switches turned on; but then there's a lot of thrashing around in that area after that, taking pictures and moving over cables and things, and it may be possible to jostle the thing. So there really ought to be a GO to leave the area when you're through with this activity for the last time. It might save a trip back.

MITCHELL I had no particular problems getting the SIDE out to the site, after we finally got it off of the subpallet. We deployed it to the southeast as planned. It eventually ended up to the southeast, with a CCIG to the south as the photographs plainly show. However, it was really a hassle getting the SIDE and the CCIG deployed. The number 1 problem was that the leg configuration on the SIDE is totally unstable in one-sixth g. The small mass of all of that equipment makes it so easy to touch, to turn over just by a touch. The cable stiffness is still a problem on the SIDE and the CCIG. Just by touching the CCIG cable, I turned over the SIDE at least three times — just trying to pick it up and also trying to hold the SIDE, the CCIG, and the ground screen and to manipulate those three things. It had been fairly easy in simulation; I had worked it out where I knew how to handle it. I still got all three of them wrapped up. I had the grounding wire to the ground

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(CONT'D)

screen and the CCIG all wrapped around each other, and it was just one hell of a mess. It took quite a bit of time to get all of that sorted out and properly deployed. It finally worked out but it was very time consuming. The major problem with the instability of the SIDE on the three legs was that it tipped over so easily. The plastic memory in the cable was just very hard to work with.

I'll start on the thumper geophone. Although I complained a little bit about getting the mortar pack off, it turned out that it was not too bad to get off. We had worked with that piece of equipment and complained about it enough in simulation that in real time the mortar pack came off very well. The pickup fitting turned the right direction and snapped into place, the antenna snapped into place very well, and the legs snapped into place very well. I had to work with the footpads a little bit because they rotated. Although I put them in the proper position for deployment, in getting it onto the lunar surface, the footpads rotated back around to the wrong position again. I had to pick it up and rerotate them to get them properly established. After I set that in position, I started out with the thumper geophone. The thumper geophone deployment was not particularly difficult.

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MITCHELL The tension on the cables was about right. We had worked
(CONT'D) with that enough in sims so that it came off about as expected.

Deploying the seismometers into the surface was a bit of a trick because of the softness of the soil. I had a little bit of difficulty getting them under my boot to push them in. Eventually, in all three cases, I ended up using the thumper plate itself. I would dangle them above the surface, pick up the thumper plate, and very carefully get the little stake started into the ground. Then I would step on it and push it in. However, the soil was sufficiently light and non-cohesive for the first few inches so that the seismometer had nothing that would hold it in place. This is the reason the second one pulled out. All you had to do was just touch it, and it either would tip over or pull out completely. When we finally got them in place, they were all within the 7-degree constraint. I'm sure they were. The second one was until it got pulled out; but, when it was eventually reset, it was all right also.

In using the thumper geophone, the trigger was very difficult. I started out by selecting zero. That was a moment of confusion. By selecting zero, it took almost more strength than I had to fire those first few initiators. I don't know why.

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(CONT'D)

I was having to fire them by putting both hands on the thumper geophone, gripping it between my palms, and squeezing in this fashion. Sometimes it would fire and sometimes it wouldn't. The first few that fired took every bit of strength that I had to squeeze that trigger. Near the end of the thumps, the last five or six or seven, it operated as I expected it would. It was a very light trigger, and I could do it with one hand very easily. Why the change, I have no idea; but the first ones were very difficult, and the last ones were easy.

We had never fired a full sequence of initiators in practice. I probably had fired only one or two just to get the feel of them. For some reason or another, I had never noticed that the numbers on the thing went from 0 to 21, which in actuality is 22 positions. I started out on zero and I didn't really know at that moment whether zero was a dead position for safety, or whether it actually had a live initiator under it. To my recollection, zero had an initiator on it, and I believe that's the first one I fired. When I got to 22, apparently I still had an initiator left so I was confused again. Had I fired 21 or had I missed one along the way? It was a little bit of comedy there that was unanticipated.

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[REDACTED]

MITCHELL The geophone was laid out in a fairly straight line; in fact, (CONT'D) a very straight line as Al's photos will show. However, near the end and pulling on the cable, it did knock over the middle flag and did pull the second geophone out of the ground.

SHEPARD While Ed was doing that, one of the things that I was doing was deploying the LRRR reflector. There was no problem with that. It's a very simple device. You just take it out, level it, and take the top off of it, which I did. I haven't heard whether they bounced anything off of it or not, have you?

MITCHELL Yes, they did.

SHEPARD Well, apparently, it was successful then.

Then the next thing that I did was to move around in the area of the total ALSEP array and photograph it, showing the documentation of the bubble levels and general location. Then we discovered we didn't have much time left at the end of EVA-1.

One comment about lighting that's pretty much the same as everybody else has said. There are, obviously, two areas where it's difficult to see on the surface. One is looking directly into the Sun, and the other is looking directly down-Sun. The only time it becomes a problem is in trying

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to read the quantity of oxygen remaining, for example, on the RCU. If you're down-Sun, the shadow is such that there's no way you can see that needle. You've got to turn cross-Sun to pick it up. With respect to looking up-Sun, I noticed that, as we were progressing in our traverse up to the Cone, we were going just about into the Sun; and the geological features and differences in craters, surface textures, and so forth were harder to notice — harder to pick up looking directly into the Sun. If we had known that ahead of time and, consequently, had planned to do most of our observing of craters looking down-Sun, and had we gotten up to the top of the Cone, we would have done it the same way. It's just something that everybody should realize. Those are two places where you can't see very well — directly into the Sun and directly down-Sun. Of course, once you realize that, I think you can adapt to it fairly quickly.

With respect to familiarization with the terrain — if we were coming at a relatively high rate of speed, as we were coming back down from the Cone crater (we were kind of running in a down-Sun direction), there were times when we had to be careful. The crater is not wiped out by zero phase. We were at a higher Sun angle. If you were running directly down-Sun, there's an area where two or three more steps and you're going

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(CONT'D)

to be in a crater. So, you're going to have to zigzag a little bit, but I didn't have any problems avoiding those things. As long as you can see two or three steps ahead of you, it's sort of like broken-field running. The whole process is so totally much slower than you are used to on the Earth. Even when you get going in leaps and long strides, you can change direction and get around the craters fairly well. You can do this even with a fairly high-speed lope.

I guess that's about it for the deployment of the ALSEP. There's one question in the Crew Debriefing Guide about transfer of the LiOH cartridges. We had no problems doing that. They were in the bag and they went on up as scheduled. Let's see — another comment on the Crew Debriefing Guide — stroking — I didn't notice any stroking of the LM landing struts. The touchdown probes were bent over, as we indicated, showing forward-direction motion generally. The markings (decals) on all the ALSEP packages were adequate, I thought. We had reviewed those pretty carefully during the preflight period. We found — because of all these little problems — that we had less time than we had thought to finish up the EVA. We did press ahead and collect this comprehensive sample. The sample was taken from an area that included a circle of perhaps 8 feet in diameter. We collected the small rocks in

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(CONT'D)

one bag. The fines were scooped up and collected in the other bag, just the way we had talked about it.

We did activate the mortar package before leaving the area, because we were getting short on time. We did pick up some grab samples on the way back. There really were no problems. I guess we finished everything on the checklist. We just had less time at the end than I figured we would have to pick up documented samples. It was just a collection of little things that got us — no one great big thing such as the things we have discussed. The adjustment of Boyd bolts, the hard things to see, all these little problems with the thumper geophone, and so forth just gradually bit into the time line.

So we did collect some samples and got on back and closed out. We found that the brush that we had planned to use to dust off the suits was effective. It did take off the first layer of loose dust. I would suggest that jumping up and down on the footpad or stomping one's boots on the ladder is just as effective with respect to the boots themselves. Just banging the boots against the ladder is enough to shake off that dust. From the boots on up the lower legs, backs of the legs, insides of the thighs, and so forth, the brush did appear to be fairly effective in getting the first layer of dust off.

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MITCHELL And effective in the sense that, after the fact, we didn't end up with too much dirt in the LM. Although we had the ETB cable all over the ground, stomping on it, and covering it with dust, when it came up into the LM it didn't have a great deal of dust on it. It didn't shake a great deal of dust in the LM which was very surprising to me. I don't know why it didn't, but it didn't. Either just the tensions and the vibration of it vibrated most of the dust off, or you shook it off.

SHEPARD The part that had dust on it never got inside.

MITCHELL Really.

SHEPARD The part between the hooks and the bag and your end of it never got on the ground.

MITCHELL That's right!

SHEPARD The part that was on the ground was the part that was going through your hands.

MITCHELL All right, that explains it.

SHEPARD All right, we parked the MET and covered it over. We didn't have any problems in the technique that we used in getting the sample return container up. Ed started up the ladder and

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SHEPARD got a couple of steps up, and I just handed it up to him.
(CONT'D)

It's a lot easier to do in one-sixth g than it is on the ground. He took that on up and left it on the step, and then he hauled up the rest of the stuff from the bag.

MITCHELL While we are commenting on moving the rock box up, on the second EVA, for example, I carried it up by myself from the ground level without any great problem at all. I just bounced up from the surface to the first rung with the rock box in my left hand.

SHEPARD I guess that the ingress and the closeout went just about as planned. We had no real problems. As for post-EVA-1, I don't believe we had any problems getting in. None of the fittings gave us any problems. The PLSS recharge went okay; the PLSS doffing was okay. It seemed to me that post-EVA-1 went along pretty much on schedule. I can't think of any problems. Can you think of any problem we had?

MITCHELL No, I can't.

SHEPARD Everything went as the checklist called for with no problems. We're back on the Lunar Surface Checklist here for a while. We found that it was easier to leave the side of the hammock that was attached to the Commander's side of the LM hooked up

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SHEPARD (CONT'D) so that, when the LMP pulled it out of stowage, he wouldn't have to get down on his hands and knees, find those fittings, and hook it up. It worked out very well that way. He didn't have any problems with getting the hammock out. We have discussed the feedwater. We originally wanted to do that twice — once after each EVA. We finally reached an agreement to do it only once. I guess they received good data correlation. We haven't heard yet. We unstowed the hammocks and went into a rest period. We didn't seem to have any problems there. As far as the rest was concerned, I didn't sleep very much. I don't know whether Ed did or not.

MITCHELL Not too much.

SHEPARD Ed, was this the point where we had the problem with the urine hose?

MITCHELL This was the second time we had a problem with the urine hose.

SHEPARD Both times when we were scheduled to dump urine out of the UCTA inside my suit into the little bags, we found that the hose leading from the UCTA to the suit fitting was a little too long and it was kinked. Consequently, I couldn't transfer urine out from the suit into the bags. We got around that by

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SHEPARD unzipping the suit and having Ed reach in there and straighten
(CONT'D) out the hose. It transferred that way. We used up every
single one of those damn urine bags.

MITCHELL That's a good point.

SHEPARD We didn't have enough of those.

MITCHELL We could have used several more. There's a problem in the
stowage. The stowage of the urine bags on the right side is
great when they're empty; but when you fill them up, there's
no place to put them. They're too big to fit into the stowage
compartment, and there's just no other place to put them.
We had them stuffed everyplace until we could put them in the
contingency bag for jettison.

SHEPARD I don't know what you can do to make that rest period more
comfortable. There needs to be some place to rest your head.
I didn't have a feeling I could put my head on anything.

MITCHELL I felt the same way.

SHEPARD We did find that we had to take the boots off because there's
so much dust in your overshoes that we did take those off
before we went to bed.

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[REDACTED]

MITCHELL In training, we thought that maybe that was an unnecessary time-consuming step and we'd probably sleep with the boots on, but they were so covered with crud that I didn't want it sifting down in my face during sleep. We took them off.

SHEPARD I think that if there was some way you could make the head a little bit more comfortable that you'd probably be able to sleep a little better. We did rest and decided that, since we'd gotten a little bit behind on the time line on the first EVA, we'd probably better start the second EVA early so we wouldn't get hung up on getting back in. We didn't want to be rushed for lift-off. I'm glad we did that. It enabled us to get a full EVA period in and still have plenty of time afterwards to get cleaned up and ready for lift-off. We actually started about 2 hours early.

MITCHELL I might comment at this point back on the sleep period. Although we were only listing starboard 7 degrees, that was very disconcerting during the sleep period. Although 7 degrees didn't seem like much when you're standing in the cockpit, it seems like an awful lot, especially when you're trying to sleep. We both had the feeling throughout the night that the blasted thing was trying to tip over on us. Actually, we got

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MITCHELL up and looked out the window a couple of times to see if our
(CONT'D) checkpoints were still right where they were supposed to be.

SHEPARD We even got a little string, hung it up, and tried to figure
the angle. The platform was powered down, and we didn't have
the exact angle.

MITCHELL If we had to land at the limit of the LM envelope — a slope
of 10 or 15 degrees — I think the guys would find it almost
intolerable to work in the LM and sleep in it at that angle.

SHEPARD If you know ahead of time you're going to land on a slope of
any magnitude, what you ought to do is bang it in pretty hard
so that you do end up with the cabin level. You'll get some
uneven stroking of the gears. But you ought to pick a rate of
descent of 5 or 6 ft/sec and put in at that speed. I don't
think we stroked the struts at all. We got up, ate a little
bit and felt a little better. We rested, although not well —
were rested and were ready to get off and running again. We
powered up the IMU, the LGC and ran a P57. Again, we had some
pretty small torquing angles. All torquing angles were 0.1 de-
gree or less.

The EVA 2 PREP seemed to go as smoothly as the first one did.

This time, when we got to the comm check, everything worked

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SHEPARD fine. We stayed essentially on the time line as far as that
(CONT'D) PREP was concerned. Again, we had no problem getting down.

MITCHELL I discovered this at that point — I don't know when it occurred — my right glove wanted to move to the left and down whenever I relaxed pressure on it. In order to move it back to normal working position, it took a great deal of effort. Anytime I'd relax, it would snap over to that position. It caused quite a bit of a problem during EVA-2. It limited to a great extent the amount of things I could do with my right hand without tiring. I could do most anything but it was just slow and tedious to do it. Outside of that, there was no other major effect of the glove problem. We brought back the glove. You just have to look at it and see what the problem was.

Yes, after I said broke I wasn't sure that's what I really meant. I didn't know what had happened to it, but it was not performing as it should have.

SHEPARD On EVA-2, we stayed right on the checklist and got everything loaded on the MET. We went through the checklist, and Houston checked it with us. We had everything we needed on there. We repositioned the TV quickly and headed out on the traverse. We went around and got the LPM out.

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MITCHELL That didn't present any more problems than we expected. It was a messy four-handed operation, but that we expected and it didn't disappoint us.

SHEPARD It takes two people to do it. ... manipulating all of the equipment to get it positioned just right.

MITCHELL I might say, in defense of the LPM, it gave good readings. We had to stay on high scale most of the time, so obviously there was a magnetic field that we were measuring.

SHEPARD I thought the MET worked very well. We had been living with it for some time during the training cycle, and it had been modified a few times to take care of some of the problems. I thought it was generally worthwhile. It enabled us to operate more efficiently than we would have otherwise.

MITCHELL We would have been in real trouble trying to move all that stuff out with just a handtool carrier, and still get the same amount of work done. I think that the MET stability was good at reasonable speeds. It was not hard to pull. It did make you change your gait a little bit. I didn't feel like I balanced quite the same way with the MET as I could without it. You could pull it up to fairly good speeds without any stability problems. It did bounce and hop and tipped to turn over

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MITCHELL if you hit rocks with the wheel or if you hit a crater with
(CONT'D) the wheel. It was not too hard to stabilize it with that tri-
angular handle. Al seemed to be able to move faster with it
than I did. That's because I didn't feel comfortable with the
stability of it. When we hit rocks and things, I was worried
about it tipping over, and I really didn't want to see all that
equipment spread out over the lunar landscape. So I think I
probably tended to be a bit more cautious. When Al was pulling
it rapidly, he was controlling it well, and it didn't tend to
turn over. We did pick it up and carry it part of the way.
That was no great trick.

SHEPARD Ed was in the front of it one time, and I was in the rear. We
lifted it up and carried it.

MITCHELL One time when Al was pulling it, I picked up the back, and we
carried it. We could move at a fairly rapid clip that way.
It was not as free a pace, as fast a pace, or as relaxed a
movement as you could make without it.

SHEPARD Didn't something come off the MET one time?

MITCHELL Yes.

SHEPARD It was that little SESC can. One of those popped off.

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MITCHELL Yes, that was on the way back. I stopped and picked it up. Other than that, things did not bounce off of it. Anything that was tied down well stayed in place. The 16-mm camera started oscillating. It came out of its holddown and was just sitting in the two retaining rings. Coming down Cone Crater, it was swinging around very wildly. The magazine that we had on there didn't have any film worth looking at, although it would have been darn interesting to see it. The camera was whipping around from side to side making 360-degree pivots. It would swing halfway and swing back very rapidly, and it had come out of the tension fitting that held it in position.

SHEPARD That was really held in only by gravity.

MITCHELL It kind of brushed up against one side of the MET.

SHEPARD The closeup stereo camera had a slight flange fitting on the other side, and that baby never bounced up.

MITCHELL It stayed in very well.

SHEPARD It stayed in there just as solid as a rock. In summary, we had very little trouble with things bouncing off. Only one thing bounced off.

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[REDACTED]

MITCHELL I think that's due in large to the fact that we insisted that everything have a good retaining clip on it. All the bags had covers to help hold them in.

SHEPARD I really expected more dust to be collected by the tires and thrown up on the MET. That didn't turn out to be the case at all. We dragged it through some fine-grained stuff near the edges of the smaller craters; and, although the tires sunk in more, in that fluffy, less dense regolith, it still didn't throw up an awful lot of dust.

MITCHELL Dust didn't adhere in any appreciable amount to the rolling surface of the tires. The MET seemed to mash it down, but it didn't adhere. It didn't throw out a rooster tail as we might have suspected.

SHEPARD Even at fairly good speeds.

MITCHELL Yes, that was very surprising.

SHEPARD Did you get the LPM all done?

MITCHELL Yes.

SHEPARD I got the thermal degradation samples all done, and we took photographs of footprints.

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MITCHELL The LPM cable was very difficult to roll out. The spring in it and the backlash were such that I could roll four or five rolls and not crank up appreciably any of the tape. It was just tightening it up inside the reel. When I loosened my grip to grab it again, it would unwind three or four turns. In addition, the tape was rolling up in bends, and it looked like a giant bow, very fluffy with lots of bends all balled up around the reel. It was really a mess to handle. It took about two or three times as much time as expected to get the cable reeled in the first time. I would have objected strenuously if I had had to do it a second time, and we had planned on three measurements. I was seriously considering just trailing the rest of that ribbon behind us and taking our chances with it. It was really difficult. It was complicated by the fact that my glove problem was making the mobility in my right hand difficult.

SHEPARD I felt that we had a navigation problem on EVA-2. I don't know why we didn't worry a little bit more about that preflight. We did discuss the fact that points A and B were not very well defined. They said, "Well, it wasn't too important to get exactly to those two points from a geological point of view." This may be true, because we're supposed to be in contact with nondescript material. But it sure made it tough to figure out

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SHEPARD exactly where we were as far as the progress of the EVA was
(CONT'D) concerned.

MITCHELL Yes.

SHEPARD Until we really get a feel for navigation on the surface, there should be some strong check points to follow. First of all, it gives you a feeling of security to know where you are. You know where you are distancewise and what you have left to cover. Second, there's no question in my mind that it's easy to misjudge distances, not only high above the surface — that we discussed before — but also distances along the surface. It's so crystal clear up there — there is no closeness that you try to associate with it in Earth terms — it just looks a lot closer than it is.

MITCHELL I certainly agree with that. I think there are two problems that affect your distance measurements. One, as Al described, and the second is there has to be a little bit of distortion in the bubble. I don't know how much that contributed to it, but I think it contributed some. I believe that our primary problem in navigation was the surprise brought about by the roughness and the undulation of the terrain. We couldn't see — one set of landmarks, the prominent landmarks — our next set of landmarks from our present position. Large craters

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MITCHELL
(CONT'D)

which we expected to be able to see standing out on a reasonably flat plane were not on a flat plane. They were hidden behind other craters, ridges, and old worn-down mounds. You'd say, "Well, this next big crater ought to be a couple of hundred meters away, or 100 or 150 meters." It just wasn't anywhere in sight. So you'd press on to another ridge and you still didn't see it. All you would see would be another ridge. Finally, you'd get over to it and there it was. You could not get enough perspective from any one spot to pin down precisely where you were. The undulations over the neighborhood were probably 10 to 15 feet. Some of the big craters up to the north and to the south looked 50 to 100 feet below our level. It looked like we were in a large group of sand dunes. The wavelength of the sand dunes would be much greater here, but that was kind of the feeling I had. I never knew what to expect when I went over the ridge of the sand dune or what I was going to see on the other side of it.

SHEPARD

I think that complicated our problem. I don't know what to suggest on that. I think that we have talked about navigation problems before. We always felt that you know you'd see these craters out here. Men have planned for them and they're very well defined and we ought to be able to locate them easily, but

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SHEPARD that just isn't the case. There has to be more thought given
(CONT'D) to some better way of positioning oneself on the chart.

MITCHELL Maybe this thought will help. We could put some work into a manual method of distance estimation better than your thumb up against the LM. We need a better manual method of estimating distance.

SHEPARD I think we did come pretty close to point A, and you and I were still arguing about where in the hell point B was.

MITCHELL Yes, we were. And I still don't know. It is probably still there.

SHEPARD We were supposed to do our thing at point B.

MITCHELL Did you remark anything about the TDS? ✓

SHEPARD Only that I did it.

MITCHELL Okay.

SHEPARD I did what I was supposed to do and put it back in the bag. I was surprised that there was little adherence of the surface dust. I expected a little bit more. It didn't adhere very much. We did all the things we were supposed to do at points A

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SHEPARD and B and we felt we were in the general area of where we should
(CONT'D) have been.

MITCHELL Would you remark about your experience with the core tube where
you drilled at point A, so we can contrast it with my experi-
ence later on at Triplet?

SHEPARD Point A is where I took the double core. It went down all the
way. It went down relatively easy for the first section. The
next half of the second core wasn't bad, requiring just general
tapping; then I had to bang it very hard to get the last half
of the top core, but I did get it.

MITCHELL Did you get it in all right?

SHEPARD 1-3/4 to 1-7/8. I guess it was two cores. That's about the
deepest penetration we had.

MITCHELL It is.

SHEPARD I suggested that we use the tip of that thing for the bug
sample. We brought the bit back in a separate bag. We started
up the hill, got over the ridge, found another ridge, got over
that ridge, and found another one. There was some discussion
at that point whether we should continue.

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MITCHELL It started to get frustrating at that point. We know we couldn't be too far and yet we couldn't see the thing.

SHEPARD If we'd gotten to the point where we'd been willing to do away with the rest of the traverse, we could have made the rim all right. But I personally wasn't willing to do that. I felt that gathering more samples was the better of the two choices. We looked at the map again today and described two boulder fields that indicate we were probably within 150 to 300 feet — depending on these two boulder fields — of the rim and still were not able to see it. That was a pretty good-sized lunar feature, to be that close to the top of the thing and not see it. That is just part of the navigation problem.

MITCHELL At this point, in spite of my personal frustration — and I know Al felt frustrated in the same way — to have us stop at that point and turn around and come back was a proper decision.

SHEPARD We stopped and started taking samples there. I feel pretty sure that we have some new and strange rocks. They looked — even to our eye, without looking at them through the magnifying glass — decidedly different from some of the rocks we had seen on the way up the slopes in the crater. I feel pretty sure there are going to be some types of rocks that they haven't seen before. We took a lot of samples. We have some documented

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SHEPARD
(CONT'D)

and some undocumented samples. I think that all in all we collected quite a bit of rocks from up in that area. The people on the ground helped us by realining some of the tasks that we originally had scheduled to do up there. Some of the things, like the polar survey and the boulder rolling we had intended to do from the rim weren't applicable, so they were discarded. We started back down the hill. From the elevation where we stopped, the view down in the valley was just fantastic. But outside of that, we could see exactly where we were going at this time. We said we were going back to Weird and we could see Weird. There was no question about it.

MITCHELL It was just like the map. Fortunately, there was a boulder between us and Weird. We used it as a reference, but, if that baby hadn't been there, I'm not sure that we would have found Weird.

When we got down on the flat, it

SHEPARD It wasn't there. That's another remark about navigation.

MITCHELL Even though there was a little confusion, we were able to spot ourselves coming by Flank and then Fredo helped us to identify the one by point E. We knew where we were at that point but after we passed point E and started looking for Weird, it just wasn't there.

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SHEPARD But the boulder was, so we had a good landmark. That may be the way you'd do it.

MITCHELL We had to be within 50 or 60 feet of Weird. It was just a matter of loping over to do it. But at that time we didn't have it to do it.

SHEPARD We did get there. We sampled at Weird and then we got into the trenching business between Weird and North Triplet. I started digging the trench while Ed was documenting some samples.

MITCHELL Yes, while I was trying to put those cores ...

SHEPARD You were making an attempt to do a triple core. It looked as if Ed and I should have changed positions because it was not soft enough for him and it was too soft for me. We practiced digging the trench in the edge of the crater, because it was mechanically and physically easier to dig the trench on the side of the crater. By the side of the crater, the dust just wasn't cohesive enough to get a good sample of soil mechanics. We probably did get a pretty good idea of what the composition of the soil was, because it wouldn't hold more than a 60-degree angle on the side of the trench before it all started falling back down in. We did the best we could without it. We were

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SHEPARD
(CONT'D)

running out of time again and it was either do the best we could with that particular trench, or not do it at all. We did go down through three distinct layers (including the surface layer) of different material. They had different colors and different textures. We attempted to document this with samples. We also made an attempt to get the bug sample from the bottom of the trench. We probably did get some soil from as much as 18 to 20 inches down; but it's all mixed up with surface soil. It may not be definable as the bottom-of-trench sample. In attempting to fill the container with that material, I had a problem. Fortunately, we had two of these containers. I took the cover off. The top and bottom part of the container have protective Teflon seals. The can itself was a knife edge. It has a protective Teflon seal around it. The top also has a protective seal. When I took the first can apart, both seals came off together. This left a knife edge unprotected. We discarded that one. We went after the other one and, fortunately, that came apart all right. I filled it with material. Even after we put it in the MET, that's the one that bounced out. Fortunately, Ed was behind there and saw it bounce out, so we didn't lose it. I don't know why those two pieces of Teflon came off together. The top came off and there they were. I was looking at the unprotected seal.

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MITCHELL While Al was doing that bit of work, I was trying rather unsuccessfully to get the triple core in. The first one would not go in. I was really beating hard on it. It just wouldn't budge. I think we saved that one, put another core tube on the bottom and tried drilling again. It went in a bit further. It didn't seem to stop quite as abruptly, but it didn't go in much further; all the while I was just beating the hell out of it trying to push it in. It was only inching down a millimeter or less each time I hit it. Finally, I had to give up because it just wasn't going in any further. On the second one, I drove it in a core tube and a half and I think we got one core tube out of it. I'm sure it pressed down so that we didn't get anything in the second core. We had a lot of trouble with sample bags. We threw a lot of them away because the little metal flags that were supposed to help you roll them up were getting entangled with each other. It was almost impossible to sort them out and pull one bag out of the dispenser. Generally, we pulled out two or three and one or two of those would get lost. It was too much effort to bend down and pick them up. It didn't look like we were going to use all of them anyway. That particular piece of equipment is going to have to be smoothed out. It was time consuming and hard to use.

[REDACTED]

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SHEPARD We pressed on from there to North Triplet. We took some more samples and some photos. Then we came back into the LM area. I went out to realine the antenna, and Ed went out to the boulder field to get some more samples. I think the operation of these cuff checklists is good. We had no problems in reading them or in using them.

The gnomon was satisfactory. We mounted the color chart on the gnomon, and it proved very easy to handle. The extension handle was good. We didn't have any problem with retrieving the solar wind foil.

The closeup camera operated fine. We would have liked to have used it more but we just didn't have time to get to it. But, when we did use it, it seemed to work well.

Soil mechanics we have talked about generally. We felt that we had less dust throughout our area perhaps than the previous landing sites.

MITCHELL Did you want to mention that on the EVA comm test we never really found a boulder big enough to get behind?

SHEPARD Yes, there weren't any boulders big enough for the comm test. We were more interested in getting samples of the boulders, and I'm not sure what you would lose. Assume that you're going

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SHEPARD (CONT'D) to lose comm if you get out of line of sight and govern your operation accordingly. That's probably a pretty good way to go. It would have been nice to know whether, if you went behind a rock, you would be able to hear them; but you assume that you wouldn't anyway.

MITCHELL We'll let the Apollo 15 guys do that.

SHEPARD The closeout went about as scheduled. We had a lot of extra samples and extra weigh bags. We used them — just about used them all up.

MITCHELL A couple of things on weigh bags, sample bags, and storage. It appears to me the geologists are now wanting larger and larger rocks. Rocks of any decent size at all are too big for the sample bags, and to have to search around for rocks small enough to go into the sample bag is an unnecessary time constraint. Either there are plenty of small-size rocks, or there are not. In our case, most of the interesting rocks were too large for the sample bag, and thus didn't get put into one. When it came to stowage back in the SRC and returning the rocks that we collected, there were so many large ones that we got very few of the sampled rocks into the SRCs. Most of the rocks ended up in one of the sample bags inside the LM rather than in the SRC, which may be fine, but that's the way it was. So,

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MITCHELL most of our big rocks were unbagged; thus, we are going to have
(CONT'D) a more difficult time identifying them, I think.

SHEPARD Well, you are probably going to get some argument about that,
depending on which geologist you talk to.

MITCHELL That may be true.

SHEPARD There are going to be a lot of different opinions. We ought
to get lots of little rocks and forget the big ones. Other
guys are going to say they would like to have more big rocks
so they can pass them around. So, get more big ones than little
ones. I think that is going to depend entirely upon the geol-
ogist you talk to.

MITCHELL Well, my point is you can put a little rock in a big bag, but
it's sure hard to put a big rock in a little bag.

SHEPARD We were prepared to go either way. We had a little tag in the
little bags, but we didn't split any of the little bags.

MITCHELL No, I don't think so.

SHEPARD They all held together. We were pretty well prepared to go
either way. We had more than enough containers to collect what
we had time to collect in that particular time period.

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MITCHELL Except I felt a bit disappointed with the sketchy documentation we did on some of those rocks, that we couldn't do a better job of identifying — putting a number on a particular rock so that we could subsequently identify which rock was picked up where. It's going to be a hard job to sort it out, I'm sure.

SHEPARD With the geologists, we may be able to sort it out very well in a matter of a day or so. We did get everything in that we needed although we made two trips with the ETB and an extra rock bag. We did get everything up there all right, with the exception of one camera magazine.

MITCHELL Outside of my own stupidity — missing that one magazine. This was complicated by the fact that, in real time, we decided to take the extra magazine we hadn't used on EVA-1 out on EVA-2, so that we had an extra magazine on the surface. In checking things off on the checklist before ingress on the second EVA, I very brightly marked off three magazines. We had three indeed. There was the fourth magazine sitting there on the camera that we just overlooked.

SHEPARD There was no problem getting in — just like before.

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POST-EVA 2

SHEPARD Everything seemed to go along pretty well here. We got the PLSSs off, got the jettison packages ready, and got everything out of there. I have forgotten exactly how much ahead of the time line we were at that point, but it seemed to me we had about an hour to sit around with nothing to do.

MITCHELL Yes, something like that. We got plenty of time to talk.

SHEPARD We had about an hour. We went in 2 hours ahead. Yes, but something else happened in there, Deke. I don't know what it was. Something else happened to take up the time. We kept busy. I don't recall what we were doing.

MITCHELL We spent a lot of the time carefully stowing. I think most of our time went to stowage after we got in — stowing all the extra rocks that we had, making sure that they went in the right compartments, sorting our weights, et cetera. This took quite a bit of time.

SHEPARD I felt that we might need the extra time. I think we sort of had a feeling that we had about an hour's dead time. At one point, I said to Ed, "Okay, we're all ready to go now. You got about an hour."

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[REDACTED]

MITCHELL That's right. That was after we completed stowage. As Deke just pointed out, we used an extra hour stowing and we still had an hour left.

SHEPARD We had no problem with recharge, changing out batteries, PLSS feedwater collection, or dust control inside the cabin. We seemed to have a little extra dust on the floor. Other than that, it was not too bad.

MITCHELL A lot of that dust, I believe, kind of got whipped outside when we did our dump repress. The cabin dust kind of swirled around. A lot of that went out through the relief valve at that point, which might have reduced it somewhat.

SHEPARD We did clean and lubricate the PGA seals at the neckrings and the wristings. I think that was a good way to go. We didn't get an awful lot of dirt, but we did get just enough of a smudge on the wiping cloth to indicate there was a trace of dust there, so I think that's a good way to go. It doesn't take too much time and I recommend doing that.

MITCHELL Yes. I think it's interesting — I don't know whether that had anything to do with it or not — but my EMU leak rate was less on the second EVA than on the first. That is completely inexplicable to me. The only thing that was different was

[REDACTED]

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MITCHELL that we lubricated the rings. Whether that has anything to do
(CONT'D) with it or not, I don't know. As I recall, I had only 0.15
leak rate on the second EVA — I mean on the pressure check
for the second EVA. My leak rate was much closer to specifica-
tion during the second EVA than during the first.

All the load numbers were good, the pads were good, everything
was in specification, and the AGS calibration was good. As I
recall, we got our updated AGS. We got the AGS time set with
a great rush. It came out to 36 centiseconds which was quite
adequate for the purpose.

SHEPARD Prelift-off checks of the control systems went all right. The
P57 before lift-off was accomplished with no problems. However,
there was a little collection of the light in the AOT for that
one. It gave a little bit more bounce off the radar or some-
thing up at the top of the LM. That was a kind of funny one
because I located the star by going to a different detent, then
swinging it on back around, and following the action of the
star around. But once I had that part of the star, I had no
problem in making the marks on it.

MITCHELL It does point out the fact that, at certain Sun angles, the
reflection off the front of the radar antenna really complicates
looking through the sextant, looking through the AOT.

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SHEPARD We got our pads all right, got the takeoff-switch settings made, got the GO for lift-off, and the circuit breakers configured. No more comments on that up to lift-off. Launch preparation was virtually no problem.

MITCHELL I think the longer time involved in launch preparation was probably because we knew we had a lot of time to do it. It had some bearing on it, Deke. We wanted to do a good stowage job. We had the time to do a good stowage job, so we proceeded to do it. In my mind, part of that time was because those weigh bags, the contingency sample, and some of those things were awfully filthy; and I wanted to make sure that they were well stowed out of the way so that we wouldn't have a dust problem when we got into orbit. That was one of the things in my mind when it came to proper stowage.

SHEPARD We had a good stowage there — no question about it. We just took a little extra time to do it. Everything was in the right place. We did have more rocks than we practiced with, those extra bags. We have done that before, and you know it wasn't anything new. It just took longer doing it. We had no hangups anywhere — just wanted to get it right.

MITCHELL I guess, with regard to stowage in the cockpit, we should comment about the ISA. It kept falling off its retaining hooks

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CONFIDENTIALMITCHELL
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over the PLSS recharge station. It was constantly in the way during ingress, egress, and ETB stowage and unstowage. The result was that we finally pulled it off the recharge station, threw it in the back of the cockpit, and left it there until we were ready to stow for lunar lift-off. It was quite a nuisance. The Commander's hoses caused a little bit of a problem in the way that we had them hooked up to the handhold. It's very important that they be run into the aft of the cockpit and then forward through the utility strap at the handhold. Otherwise, they are in the LMP's way while he is getting in and out of the cockpit and while he is trying to handle the ETB. However, with proper handling of the Commander's hoses, it is no great big problem. The ISA definitely needs to have the hooks on it reconfigured so that they will stay in position during all the cockpit operation, especially during hard-suit operations.

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11.0 CSM CIRCUMLUNAR OPERATIONS

LANDMARK TRACKING

ROOSA With one exception, the landmark tracking went extremely well. I thought the lunar graphics I had on board were quite adequate. I had spent some time before flight studying all the landmarks. It was so easy, I guess maybe most of that time was wasted now. You could take the graphics and pick up the lead-in and track the landmarks I'm sure, without having seen a picture of them with just one or two exceptions. I had no trouble acquiring the landmarks or tracking them, with the exception of DE-2. I really didn't get that landmark. I had looked for DE-2 on the REV just before the one in which I tracked it, and I couldn't find it at that point. I was looking through the window. At this time, I was in an attitude for something else but with the high Sun angle we had at the time of tracking DE-2, it just went right into the background surface and I was unable to pick up the target. I was right in the area and approaching the nadir. I did pick up a small crater in the area of DE-2 and tracked it. I was supposed to specifically track the DE-2 crater and it was just impossible to find it with the high Sun angle. The rest of the landmarks went extremely easy. I got the camera

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on the adapter, fixed the adapter, and got pictures of them. I'm positive I got good marks on all of them. One word on that sextant adapter. It was hard to get in and out each time. In reflection, it was difficult on the bench checks also. I know we talked about this. I felt like we needed a little graphite or some sort of lubrication on that adapter. I had it in and out of that panel quite a few times. Each time it was difficult to get it in and out. Landmark tracking at low altitudes was extremely easy. All the pads came up in good order, even with the comm trouble.

COMMUNICATIONS

ROOSA

It seemed as if each AOS was difficult. You could acquire with the high gain and it would be showing a signal strength that should have been adequate; but you had to go to MANUAL, WIDE BEAM width, twist the dials, get it locked up again, and then go back to MEDIUM or NARROW. You just couldn't believe the signal strength meter and say that I've got a good lockup now. Why this is so, I have no idea. We spent most of that first day using MANUAL and MEDIUM BEAM width. Somewhere toward the end of that day, we tried AUTO and it worked well; for the sleep period, we cut the dead band down to 5 degrees, I believe, so they would hold the comm

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ROOSA
(CONT'D)

better through the sleep period. So, the communications seemed as if they were always marginal. I would come around and approach the other terminator and we would get good comm and would get all the data passed up for the next REV. Coming up the other side, I would concentrate mainly on getting my flight plan finished rather than worrying too much about the comm. I would try to get the comm; and, if it didn't work, I'd press ahead with my flight plan, knowing that I'd pick the comm up again later.

PHOTOGRAPHY

ROOSA

I think I'll lump all the dim-light photography under the one area and say that the procedures were rather complicated. However, I had run through all these in the simulator. I was well squared away on them in flight. I had no trouble at all with getting the experiments done in the time available. The dim-light windowshade fit well. After our final bench check, in which we squawked about the length of part of the shade, I didn't have a chance to check it again. Ray Dell'Osso did. He said it went fine and anything Ray said, as far as I'm concerned, was correct. The shade fit exactly in flight as it should have. Just as added insurance, I did tape the floodlights which are up by the right-hand

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(CONT'D)

rendezvous window so that, when I turned off the floods, I wouldn't have the residual glow from that set of floodlights because they were right up by the window. I put a piece of tape over the green shutter light so it wouldn't be blinking right by the shade. In most cases, I turned out all the spacecraft lights and operated the camera with the remote cable, counting the time with the timer down in the LEB. If there was a chance for the dim-light photography to work, it should have been on this mission because I was, in most cases, in total darkness.

I would like to comment on gegenschein photography. The first time we came to it, I had inhibit A-3, C-4, B-3, and D-4, the forward-firing thrusters. The rates looked low; so I turned off all the thrusters and went through this sequence. There must have been a little residual rates left on one of them after I finished my exposures. I checked the attitude and we had drifted off about 3 degrees. I don't think this is any problem at all, but I just want to let the experimenters know that about the first gegenschein photography. I was trying to do a little extra on this one also, by turning off all the thrusters; and we got about 3 degrees off in attitude. I didn't do that anymore. I only turned off the forward-firing thrusters from then on.

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[REDACTED]

ROOSA I have confidence that all of those turned out extremely
(CONT'D) well.

ZERO-PHASE OBSERVATIONS

ROOSA One comment on the configuration for the zero phase. It calls for the PCM cable, and the 70-mm PCM cable is not long enough to reach when you have the camera mounted in the hatch window. As far as I know, I had never tried to hook this up before flight, with the camera in the hatch. We did not have a bracket in the simulator. We barely got the one for the flight there in time. So, that was one minor change in configuration for zero phase, as the PCM cable was not used. I spent quite a bit of preflight time worrying about my targets on this one. Some of the targets on the back side were rather obscure. I felt I was really up on them, and on that first "Gee whiz, look at the Moon," after LOI, as I was coming across without the aid of the map, I picked up most of my zero-phase targets. I think I called several of these out over the loop. I felt real confident from that point on that I'd have no trouble at all picking up the zero-phase targets. I was quite surprised by the zero-phase observations. When you're on the back side, you can pick up the target quite easily because it's at a good

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Sun angle and moving toward the zero phase. So, acquiring the target was no problem in most cases. I had plenty of visibility around the hatch - around the camera mounted in the hatch window. But I was quite surprised at the loss of visibility of these targets on the back side, when you did get to zero phase. I put most of this information on the onboard tapes. It should be there. In general, according to our rating system - and I applied this rating system right at the zero-phase point - on area 1, I rated A as low, B as medium going to low, and C as zero.

SPEAKER You mean you couldn't see it all.

ROOSA Zero means no acquisition of target or target area. This was phenomenal. You could have C in view and as it moved into zero phase, it, and everything around it, was completely washed out. Now, the real key to seeing the target at zero phase or above - and, by above I mean with the zero-phase point moving away from me. You have no good contrast in relief on the back side. Now, on the front-side targets - say you had a flat mare surface and a crater on it. Even though the crater was not bright, you still had a relief. You had the flat surface broken up with the crater rim. Then it was no problem at all. I only got to shoot two front-side targets

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as the others were canceled because of the Descartes photography. I had no trouble acquiring targets 3 and 4, following through zero phase, or seeing them exactly at zero phase. But, on the back side, on targets 1 and 2 you really lost it. There was just the lack of physical relief - structural relief between the target and the surrounding terrain. And on area 2, we only had targets A and B. I rated A medium to low, and B was an absolute zero. It had nothing whatsoever to do with zero phase. I didn't have any confidence pre-flight that I would be able to see target B. I couldn't find target B at low Sun angle, good Sun angle, or bad Sun angle. I looked for that thing on several passes before my actual observation of it. I sat through several briefings in which the PIs would discuss which crater was B and they would look at these photographs a long time and so B was purposely, I guess, a very difficult target. And I couldn't find that thing, and it didn't have anything to do with zero phase.

SPEAKER Too small?

ROOSA Well, it was nondescript. It was supposed to be a crater, but it was in a general rolling area with craters all over the place. You're right in the area. I couldn't say

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specifically I saw that crater. Zero phase didn't affect that one much. I also got a chance to look at target 1 on one of the other passes coming around. It repeated exactly what I'd observed on this one when targets A, B, and C went into zero phase. Target C was completely wiped out. I was quite surprised. The structural relief is the best help that you can have. So that took care of zero-phase targets 1 and 2. I gave a mark on the tape recorder when I turned on the intervalometer and I gave a mark when I turned the intervalometer off. I did notice the camera, approaching the zero phase. It seemed as if it clicked quite close to zero phase on just about each pass; so I think that the ground T-start times were good. We should have gotten a picture very close to zero phase on each target. While I'm speaking about the intervalometer, it had quite a few of double actuations on it just as it did in our bench check down at the Cape. We mentioned that, and they completely inspected the intervalometer again. It still had several double actuations on it. The switch target time didn't work out too badly. I set up my timer to give me a gross time to switch, to alert me that my switch target time was coming up. Then I switched it the exact second by using the event timer and/or my wrist watch. Then I finished up targets 1 and 2. I came

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around to the front-side for zero phase on targets 3 and 4. I just read you word for word what my comments in the book were. That's probably the best data we've got. The dark mare surface made a good contrast with the bright crater rims. That's easy to identify. On the back side, where surrounding terrain is almost the same albedo as the crater, it really gets wiped out at zero phase. Now, I also want to amplify that statement, particularly on target 3, where we had a rather subdued crater in Ptolemaeus. I didn't have any trouble at all picking it out. Now, targets A and B were on the flat floor of Ptolemaeus. I could find the general area real fine by that little, small bright crater to the right of B, but crater A was not a bright crater. It was subdued, and I specifically concentrated on A as it went through zero phase and it hung in there all the way. So there's really a marked difference between front side and back side as far as zero phase is concerned.

Zodiacal light was probably the most complicated of the dim-light procedures and it went well. I ran that thing and ended up right at sunrise. I ran off my strip and the sunlight came into the spacecraft. It was right on schedule. About this time, I got a call from the ground to make sure I had saved a couple of magazines because they were then

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thinking about the 500-mm backup for Descartes. I'm a little surprised that we didn't shoot Descartes on the first day with the 500-mm to get the lower Sun angle. I don't know if this was ever discussed on the ground or not, but being suspicious of the Hycon, it seemed maybe we should have shot it the first day and bypassed some of the landmarks. Anyway we didn't. We went into another series of landmark tracking and I've said enough about those.

The orbital science photography was specifically some handheld strips that had been coordinated. I did not just want to shoot targets of opportunity. I wanted specific targets laid out that I knew I could shoot; where we would get the most scientific gain. We had several of these and, on the second day, almost all of them were scrubbed. On the first day, I did get in about four of our targets. And as far as I know, the pictures should be good. Some of these were some long strips you had to take with the spacecraft attitude that we had. We had no specific attitude for the photography. For a couple of these, I was crammed up against the panel trying to get that 500-mm lens in the right area. But we knew in advance they all may not be suited for a certain window, but I believe I got the four handheld targets on

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ROOSA that first day with good results. We'll have to see the
(CONT'D) pictures. I've already commented on the Hycon.

PLANE CHANGE

ROOSA Coming down to the plane-change burn was just like any other burn. I was well ahead of time. I made sure that I didn't get behind, and I scurried around and got all the equipment secured. I was well up on the time line coming into it. It was a nice long burn, 18 seconds. It went real well. MSFN got the telemetry. I guess there was some doubt or some questions before flight about getting P40 data, but they got all the data. They were in a hurry at this point for me to go ahead and get started on the maneuver. So, I just let them read the residuals and I proceeded and didn't even write any down, as soon as I knew they had them. I think the largest residual we had was 0.6 in X on this thrust. I then went into earthshine. I had to go through the gyro torquing and I got the cameras configured for the earthshine photography. That's rather a tight time line. I knew it was going to be. I had simulated it and I made it with no problem. However, it was tight trying to get ready from the plane-change burn to start the earthshine photography. Here again, I couldn't use the windowshade because we had

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both cameras out the right-hand rendezvous window. I finished up at that pass. That took me up through the end of day 1. I knew the next day was going to be an extremely long and an important day, so I went through my presleep checklist, had something to eat, and tried to get as much rest as I could. I didn't work on the Hycon that night.

OPERATION OF SPACECRAFT

ROOSA

I guess I really don't have anything to say on that. We didn't have any problems to speak of. The thing went as simulated. The only problem was our communications and that seemed always to be there as a nagging problem. I didn't sleep any better, any worse as far as the solo period was concerned, than I did when we were all in there. I didn't have any pangs of loneliness or anything like that. I got up the next day. I had gotten all my magazines and cameras configured because, from the simulations, I knew the second day started in full afterburner, and it did as advertised. As soon as I got up, I had some more cameras to configure, a little bit of talking with MSFN, the VERB 49 maneuver for the bistatic radar experiment (the uplink is dropped, and I'm into the bistatic radar experiment). Things went extremely fast. I know the first time I tried this in

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simulations that I was behind and didn't get my ORB RATE started right on time. So I had run through this several times after that to make sure that I wasn't caught behind. It's a variable ORB RATE, so if you don't get started on time, you've got a little mathematics to worry about because you're really pitching this 0.0830 instead of your normal ORB RATE. I have no idea how the bistatic radar experiment went. I got no comments from Mission Control on it. We got configured correctly and blasted the lunar surface with the various antennas. During this bistatic radar pass, I had a long strip of handheld 250-mm photography. I got 95 percent of that long strip as advertised. I had to switch windows a couple of times because of the attitude I was in, but I knew the specific areas that were of higher interest and I got those in particular. Although not in the flight plan, I also took some handheld shots of the Crater Lansberg B, where the Apollo 13 S-IVB was located. Its impact was close to this. As it turned out, we shot that again later just before TEI in a superhuman effort, which we'll go into later. One thing that troubled me during this handheld photography during this one pass was that the windows were fogged up. I actually had water condensed on some of the windows out of which I was trying to take pictures. I noticed this just

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about on each pass. They come on the end of the dark pass, coming through the dark side. I could feel the humidity in the spacecraft picking up a little. It felt a little clammy and then I'd come out into the sunlight and some windows would have condensed water on them and some wouldn't. But coming across the front-side pass, everything would clear up and I would be ready for the next one. It was not a major problem, except in this case, as the water was on some of the windows I was using for photography. I just took some tissues and cleaned them off the best I could and kept clicking away. After that one, I went into the dark side and started the vertical stereostrip with the 70-mm Hasselblad. I was to get about 3 minutes of high bit rate data at the start of this. As I went AOS, I went through my normal check of the tape recorder and it was not gray. So, I hit the switch to FORWARD, COMMAND RESET. The tape recorder went gray; then I forgot about it. I didn't check it again until I got ready to start my vertical stereo, at which time I looked down and noticed that the tape recorder was barber pole. I tried a COMMAND RESET and it wouldn't go forward. Sure enough, the tape needed to be rewound. During this front-side pass, during the bistatic radar experiment we had no uplink. The ground did not have a chance to rewind. I saw it just before

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the start of this vertical stereo. I hit the REWIND and got in a few seconds of REWIND before it was time to start the camera. I went to HIGH BIT RATE and START. I probably have about 45 seconds of high bit rate instead of the 3 minutes called out. We did definitely get the start of the strip on high bit rate, but it was not as long as we wanted. This is something I had never thought of before. The ground had not either. Then came the front side in the attitude and with the 70-mm getting our vertical stereo. I had the hand-held strip on Langrenus which went well. I had a good attitude. I had no trouble at all on that photo target. At the end of this vertical stereo, I tracked the landmark with the COAS to calibrate the camera coming across the front side. The ground had decided that this time we would be shooting the 500 mm on Descartes instead of the Hycon. I had been doing some talking and going through the troubleshooting procedures on the Hycon. They had duplicated the problem on the ground and had decided that it was too marginal to trust; so we talked a little bit about the COAS tracking procedures. In the normal flight plan we do have this COAS track to calibrate the 250-mm lens at the end of this vertical stereo. So I had tried it in the simulator. It doesn't work too well there because of the cloud occultations, but it was

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enough to check out the procedures. In flight, it went much easier. The procedure I used for the COAS track was to start in CMC, AUTO, RATE COMMAND. When I picked up my landmark, I would command a full pitch and when the needle got down to my half a degree command, I would then switch the mode switch to FREE, give it a few clicks on the minimum impulse to drive the rate up to around the 0.7 to 0.8 that you need and then fly minimum impulse for the rest of the tracking. It went quite smoothly. I finished up with the vertical stereo and at this time I received an extensive flight plan update canceling all the Hycon and putting in some new attitudes and procedures for Descartes. I used the back of the Solo Book and the back of a couple of pages towards the end. I think the Solo Book should include two or three extra blank pages to write down procedures. The procedure for the COAS tracking was an 11-step procedure. I covered up one whole page with it. You just don't have room to write that in your normal time line because you already have so much in there.

If I had needed anymore procedures, I was just about out of paper. We have blank pages for checklist updates and they're in the back of the Malfunction Procedures. We have plenty of blank pages on board and I guess my point here is that we should have a couple of blank pages in the Solo Book. It was

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no problem. I had room to write, but if I had received two or three additional long procedures I would have had them scattered all over. At this time we canceled all the rest of the handheld photography and worked primarily on getting the Descartes 500-mm COAS tracking. I thought this went quite well from my end. Descartes is an extremely easy landing site to pick up with the two bright craters leading right in. There's no way one can miss it. I thought my tracking went well. I just looked at the pictures and I'm quite satisfied with them. We have some real good 500-mm shots. The first four, five, and six frames, I was manually clicking off every 5 seconds. It sure would be beautiful if one had a variable intervalometer that could be put on that camera instead of the standard 20 seconds. When you're concentrating on keeping the COAS on the target, counting 5 seconds, and clicking the camera, it is sort of a three-handed operation. A variable intervalometer would have eased that problem. I noticed on the film that the first five or six frames are overexposed. I fired right down the settings that they gave me. They were 1/250th, at f/11 and at infinity. I was consistently shooting about 40 frames. They asked for 42 frames a pass. I was very close to that each time. I feel real warm about that COAS photography. DE-2 was an

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impossible landmark. It shouldn't have been in there at that high a Sun angle. I did do the second set of back-side zero-phase targets. They went down the line as I commented before. I made a lot of comments on the tape. I'm sure that the PIs and I will get together on those. In area 5, I listed A as medium, B as low, and C as low. In target 6, I listed A as zero, B as medium, and C as medium to high. For any further details on that, we can refer to the voice tapes. I made my third COAS pass on Descartes. I did not get the high bit rate on. The tracking was good. The pictures were good, but we did not get the high bit rate. I called the ground and told them so they were aware of this.

At this point, I started to get things organized for the rendezvous. I had done almost all of my housekeeping earlier during the previous passes. If I had waited until I got up to 141:30 in my time line and had tried to do all of the things that it said there, I never would have made it by the time we had LM lift-off. Whenever I had a chance, I would go ahead and do things like installing the cabin fan filter. I took out the vacuum cleaner and had it assembled and stowed. I got all my pouches off from B-5, B-6, and so forth. I really jumped ahead on this and I was glad that I did. I set up my camera. It showed an eat period in here. I did

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grab a fast bite, but most of that eat period was taken up with getting the spacecraft configured for the rendezvous. I put my suit on. I had no trouble with the suit donning. It went just as advertised, and that brought me up to LM lift-off.

One other area to include here would be my visual tracking pass on the LM. We changed the coordinates of the LM slightly. I received an update to NOUN 89 values. I also took the coordinates off my site map. I bombed into the area. I had no trouble at all. I had really smoked over the Fra Mauro area and had certain lead-ins coming into it. I picked up Cone Crater and Triplet and had no trouble identifying the area. I was looking on my map at these coordinates, and they were wrong. They had the LM over on the other side of the Triplet. Then I saw the bright spot - the reflection of the LM and the shadow. There is no mistaking the LM when you see that long shadow coming out from it. I had a real good track on the LM. I don't remember how many marks I took, but I got a good track on it. Then I changed the coordinates on my site map and told Ron that I put the LM at different coordinates on the site map. The next day, between the two landmarks that were listed, I had a chance to look at the landing site again. This time the shadow in the LM was

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down, but I knew exactly where to look. I saw the Sun shining off the LM and also off the ALSEP package. I marked down the coordinates of the ALSEP and phoned those down to Ron. It looked to me like the ALSEP was right out there by this crater.

I would like to comment on the sextant image. The image was not absolutely sharp. When you are looking at stars, there is no problem. When you look at the lunar surface, the surface always looks a little out of focus. It is not enough to bother your acquisition or tracking but is just enough to blur the fine detail.

SPEAKER I noticed that, too. It is just slightly blurred.

ROOSA Yes. I have one more comment on this rest-and-eat period in the solo phase. I had looked at my time line with a pretty critical eye and felt that everything was adequate; but when you toss in a troublesome Hycon and a lot of troubleshooting, you can use up your eat period in a hurry. I thought the cans of the chicken salad and the bite-size foods were really the only practical food that I had to eat. I didn't have the time nor the inclination to try to mix any hot foods with water. That was a good plan for me anyway because I like those kinds of food better.

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12.0 LIFT-OFF, RENDEZVOUS, AND DOCKING

SHEPARD We had no problem, we had an automatic ignition on the PGNS. The ascent stage went to local vertical smoothly, right after lift-off. From its landing attitude, I thought ascent was just about as we expected. I think that you'll see in the film out the window that pitchover started right about at 10 seconds and the dead banding of the ascent stage in pitch continues all the way into the shutdown. The comparison of the PGNS and AGS parameters during lift-off were good. I really had no concern at all during any of the ascent phase. We didn't have any anomalies that you noticed that over there, did we?

MITCHELL No. I might remark that I was left occupied with physical things. The staging (that was shown on the film) blew out an awful lot of crap from the interstage area; a lot of Mylar, I guess, shrapnel from the bolts. A lot of things blew out and it looked pretty messy on the screen as it happened. The staging sequence and the thrust onset made a pretty good shock. There was no buildup of thrust; all of a sudden it was there, and we were flying.

SHEPARD There wasn't anything unexpected at all. Everything went about as advertised. Ed did his little roll thing on the main -

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SHEPARD (CONT'D) and the ascent phase. I was all set to shut down to prevent any overburn, but the PGNS shut it down with very low residuals, which we trimmed out. As a matter of fact, that was when we had a ... tweak burn.

MITCHELL Everything was just right according to the book.

SHEPARD The tweak was a minus 2 feet in X, plus 5 in Y, and minus 8 in Z. We were in attitude ready to burn. There were no problems. I punched in the breakers to get a lockon with the radar. We did not lock, which surprised me, but here again it may be part of the problem we had before, where maybe our rendezvous radar was drifting away from where we thought it was. We didn't get very excited about that. We came on around after the tweak burn and went into P20 and got a lockup right away, and started updating. We called up P34 and started our rendezvous navigation. Everything went right by the money, right by the book, we had no anomalies at all.

SHEPARD I was watching PGNS. We had a single NOUN 49, which meant that the PGNS knew exactly where it was.

MITCHELL The vector was good.

SHEPARD The vector was good.

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MITCHELL AGS looked good on insertion. AGS updating was started at 28 minutes. I might point out that, although we were completely nominal with no problems, we did not get the 30-minute R/R-dot mark for the backup charts, which essentially makes those charts worthless if you don't get that first one. I have no explanation except the fact that time just moves faster when you're in that situation. Everything was absolutely nominal, but we still didn't get the 30-minute mark. I was surprised when I got the clock set and was ready to go, and the clock was showing 29 minutes. I started updating AGS right after that and kept a completely independent AGS solution throughout that navigation portion. — The AGS and PGNS H_A and H_P , as we compared them through the burns, were hanging in there very close. We had good solutions on both computers.

ROOSA The simulations were correct on the comm. During all of the sims, I had extremely marginal comm, but I always had good comm with the LM. On this flight, I had almost zero comm with the ground, and almost zero comm with the LM. Our VHF was extremely bad between the two vehicles. I did the two or three things that we had gotten briefed on (that's got to be at least a year ago now). I turned the ranging off to see if we could talk between the two vehicles, and I played with my squelch. As I remember, those are the two things that they

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ROOSA (CONT'D) stressed in our briefing: to get rid of the ranging and to watch the squelch. The squelch had not been moved since the PAD so I tried both those. We had literally no VHF comm between the two vehicles.

MITCHELL Certainly not at that point.

ROOSA Yes, at this initial point, VHF ranging was certainly acting up. I'd get my tones just as advertised, the thing would lock up and then maybe stay on for 1 or 2 seconds, then drop out. Or it might stay on for quite a few seconds, long enough for me to get an update, a NOUN 49. They were always bad; I was getting some bad updates on the VHF. I kept rejecting them. I got one that was somewhere down in the order of 5 miles or something like this, and I accepted that one because it seemed pretty reasonable. I'm not sure if I accepted more than one; but, anyway, before we went LOS, MCC called and said that that was a bad VHF mark, to discontinue the VHF markings, to do a VERB 93, and to reinitialize the W-matrix. I sort of questioned the reinitialization of the W-matrix, but they said to do it, so I did. I did it with a VERB 93 and a VERB 88 and pressed ahead with sextant only from then on. When I had time in between my sextant marks, I played with the VHF ranging. I'd get it back up again at times. I got a lockon and everything

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ROOSA (CONT'D) looked good. At 143:06, which is maybe 4 or 5 minutes before TPI, my range on the VHF showed 18 nautical miles. That was a little before TPI and obviously was an erroneous reading. I was not accepting any of this. I was just trying to see if I could get the VHF going. I couldn't. Other than that, the sextant marks went just as advertised. I had no trouble seeing the LM tracking light in the telescope or the sextant. It was a no-sweat deal to take the sextant marks, but the VHF was out to lunch. I'm not sure why. I don't have any answer on that.

SHEPARD Now you got locked up very well one time, when you told us to be quiet.

ROOSA That was after TPI.

SHEPARD That was after TPI?

ROOSA Right. After TPI, then we had good comm between the vehicles.

SHEPARD The VHF B had come back in about then too.

ROOSA Yes.

SHEPARD The VHF B was bad before then.

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ROOSA Yes. I had tried the other antenna; I tried the antenna squelch and ranging off to see if we could do any good, and none of those really worked. So after we burned TPI, I asked everybody to be quiet for about 20 seconds to see if I could get a good solid lockup. It locked up and stayed with me through the midcourses all the way down to TPI.

MITCHELL I think one of the significant questions is why we didn't have VHF B. And once we answer that, we might have an answer to why your ranging wasn't coming in.

ROOSA Yes, and I'm not sure that it was the failure to lock up because, as you know, I got locked up enough to get these erroneous ranges. It was not a problem of never locking up. It was the problem that I was getting bad VHF ranging data.

MITCHELL I think our talking in the cockpit would prevent your locking up.

SHEPARD The modulation from the voice shouldn't have made any difference.

ROOSA No other crew has said that that has made any difference. In fact, they have stressed the point that you could go ahead and lock up with the LM crew talking to each other. But our comm wasn't even good enough to discuss the situation at the start of the thing.

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MITCHELL Yes. We could hear you sometimes very faintly, but you were way down in the mud.

ROOSA That was the problem from my standpoint. We essentially didn't have the one sensor up to TPI.

SHEPARD Well, we got the TPI solutions on time.

MITCHELL The PGNS and the AGS completely agreed. They were within about 1-ft/sec of each other. That's 1.6 ft/sec on TPI DELTA-V. They agreed within 1.1 ft/sec on total DELTA-V TPI plus TPF. So the solutions were right together.

SHEPARD And your solution was right in there too.

ROOSA Yes. Ours was pretty much within the limits of our comparison criteria. I didn't write it down. It seemed like — on the new W-matrix — I had something like 12 or 14 sextant marks; I've forgotten. But I didn't write it down like I did some of the others.

SHEPARD There wasn't any problem deciding that we had good solutions. Because PGNS was active, we went ahead and made it a PGNS APS burn.

[REDACTED]

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MITCHELL Yes, but I retargeted the AGS to the PGNS solution rather than leave the solution independent, so that we would have a backup on the burn.

SHEPARD We burned on time. The attitude change was such that we maintained radar lock through the burn, and we just continued to proceed with the PGNS solution for the midcourses.

ROOSA We agreed within 0.5 foot on each one of the midcourses. I've got your midcourses here that I loaded. You had 0.9, 0.2, and 0.6. I had 1.3, 0.1, and 1.1. So we were very close on it.

SHEPARD We were very close on MCC-1. We burned minus 0.9, plus 0.2, and 0.6. On MCC-2, we burned practically nothing — minus 0.1, plus 0.1, and minus 1.4. We had a little Z in there.

MITCHELL And all residuals were plus one-tenth after that burn.

SHEPARD Yes.

MITCHELL So we had very small differences; these all agreed with the polar chart.

SHEPARD We came in with the braking on schedule, went through the braking burns, and ended up right in there. So from TPI on in, everything was nominal.

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MITCHELL The AGS strategy was to initialize after TPI, and I did not initialize after the first midcourse. I continued to keep the AGS independent and updated it. The AGS solution was on the order of 9 ft/sec at the first midcourse, which is generally about what you see in the sims. But the AGS hadn't really converged by the first midcourse after initialization at TPI. I did not initialize after the AGS second midcourse, because the PGNS differences were so small and the AGS was right in the same ballpark. They were on the order of tenths and 2 or 3 ft/sec in Z. I discontinued updating the AGS after that point except to prepare it for the braking. Shortly after that, the AGS failed us, and the ground called us. I had not looked at the AGS in some time. I was configuring the cameras for the braking phase and the docking. When the ground called us, I went back to look at AGS and got no response out of it. In fact, I think that we had already completed braking and were stationkeeping. I'd called up 470 to monitor the braking phase to give us back the DELTA-V monitor during braking, and 470 did give a proper readout. So the AGS obviously failed after that point. There was no AGS alarm. None of the circuit breakers was out. The symptoms were that the FDAI AGS ball remained locked at the point at which it failed. I don't recall those readings. There was no way that I could get into

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MITCHELL DEDA to call up numbers or to but in numbers. The DEDA was (CONT'D)
completely blank. I did note, after that, that the inner glass on the DEDA address register was cracked. The outer glass did not appear to be cracked at all; it was cracked down inside the DEDA itself, probably where the register numbers are actually displayed. There was a fairly healthy crack in that glass.

SHEPARD We came to formation flying position about 100 feet apart. And Stu did his pitch maneuver. From visual inspection, we noticed nothing unusual on the command module or the service module. We also had photography, of course, to go along with that. But the CSM looked good and clean, even the engine bell was clean, nothing unusual or unsymmetric about the burning pattern in the engine bell. We had been given instructions by the ground for the docking. They wanted us to thrust some with the PGNS at plus-X during the docking. We discussed that with Stu, and we mutually agreed that it would be better to give it one go at least using the normal technique with no thrusting. That we did, and it worked fine.

ROOSA Yes, we discussed that on the backside. We really didn't see any advantage to that LM thrusting. I was shy of that. I didn't like that idea of the LM coming on with thrust. We

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ROOSA
(CONT'D)

didn't see where we had anything to lose by trying the normal docking method. If it didn't capture, then we'd try it.

Docking went smoothly; it worked like advertised that time. There was almost zero oscillations of the LM. I don't know whether it showed up on TV or not. I had the TV camera running, but it hit and the talkbacks went barber pole, and the LM sat there. It was no problem at all. One thing about the LM insulation (it showed up on the TV) — the bottom insulation on the bowl, whatever tank sticks out there, was ripped from your staging. The insulation was torn and flapping out. There was a big rip across the gold insulation.

MITCHELL That would be either the oxidizer or fuel tank.

ROOSA The other side was nice and clean. This had some big strips flapping. I'd say probably there was a 2- or 3-foot tear in the insulation. So, anyway, we hard docked with no sweat. We actually felt real warm on that probe because of all the times we had banged it in and out of the drogue, and checked the capture latches, rechecked them. I guess we still have a big mystery about the first docking, but we felt pretty warm on the probe. We discussed what we would or wouldn't do in the event of not getting capture. I think our confidence level was very high that we were going to have a normal docking.

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As we came into the docking, I think somebody was putting the pressure on Bruce for me to change the LM weight in the DAP. I must have gotten five calls on changing that LM weight. My procedures, when we get a capture, are to go to CMC, FREE. You either stay in CMC, FREE, or you go to SCS control for attitude hold until you've reconfigured the DAP. I know somebody was putting the pressure on Bruce on that one, so I changed the DAP while I was pitching around just to keep everybody happy. Then sure enough, after I got in and went to CMC, FREE, and was sitting there going down my checklist in which it says, "Verify the DAP load," they gave me another weight that was different. I had gone to all the trouble to load the first one while I was pitching around, so I guess I got a little irritated at that call. Somebody was worrying about that LM weight when they shouldn't have been.

MITCHELL It's not really critical anyhow at that point.

ROOSA No, you're not doing an SPS burn or anything. Your procedures are all set up to go to FREE; then you get your DAP squared away. They must have been talking to Bruce pretty heavy on it; he called us several times.

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13.0 LUNAR MODULE JETTISON THROUGH TEI

SHEPARD In the LM, we started unstowing and making preparations for transfer right away. One of the first things we did was to get the hatch open. We didn't have any problem with that on the LM side. Of course, it's a fairly easy procedure. Did you have any problems with the hatch or probe, Stu?

ROOSA No, the pressurization is supposed to be brought up to the command module before the hatch is opened. It's also part of the presleep checklist to bring it up to 5.7 each night so that cabin pressure decay can be watched. So, the night before we docked, I brought it up to 5.7 and it held pressure all through the next day. When we docked, the cabin was already at approximately 5.7 or 5.8. The first thing I did after we got docked and got the cockpit cleaned up was to take off my suit because it's so much easier to handle the tunnel and the equipment transfer without being hooked to the umbilical hose. I put my suit underneath the couch and cleaned up the switches. Then I went right into opening the hatch, and I didn't have to wait to pump the cabin up. I took the hatch off and brought the probe inside. You removed the drogue and took it into the LM. I never even got my hands on it.

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SHEPARD We arrived there at the interface at about the same time. The original plan was to stow both the probe and drogue in the left-hand side of the LM cockpit. But since the probe was to be returned, all we had was the drogue, and it fit in there very easily. We practiced that postdocking transfer just one time in Houston using both the CM and LM mockups. We did it over the Christmas holidays, as I recall, just before New Year's day. Since we practiced late in training, all the procedures were fairly well established, and for the most part, that one practice session was adequate. We didn't have too much of a problem in getting things back over there.

MITCHELL I think we probably got our suits off a little earlier than the checklist called for. I'd recommend that to future crews: get the suits off as soon as you can. It certainly improved our mobility. One of the first things you do after you get the tunnel open is get those suits off and get them brushed down and stowed. It makes it a lot roomier in the cockpit and gives you easier access to everything in the cabin. We were a little bit hesitant when we planned, in the time line, to remove our suits that early in the game because of the dust problem. But we went ahead, took a chance on it, and wrote it that way. Since we didn't have any dust, it worked out real well.

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SHEPARD Yes, the suits seemed to come off pretty hard. Of course, we had them on a long time, and we had some perspiration in them. I guess they were pretty well fixed to us; consequently, they seemed to come off a little hard.

MITCHELL They did.

SHEPARD I don't know exactly why that was, but it did take a little extra time to get those things off. I guess because it's easier to bend the upper torso down and get the V-shape necessary to get your fanny and backside out of the suit under one g. We struggled with those a little more than we had in the past. The vacuuming procedures seemed to be satisfactory. I think with each pass with the vacuum brush, you could see the dust coming off. In other words, you make a pass or two on the side for example, or on the back, and you'd see the loose dust, off the top, that was still there, come off into the vacuum cleaning bag. So, that is an effective procedure. At least, you remove just one more layer of dust. Of course, the smudges were still there. I think that, as a general comment, using the procedures that we used, as written, we got very little dust back in the command module. The things that were dirty, the suits, were put away in bags right away. Stu was ready for them and they went into the bags, the L-shaped

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SHEPARD (CONT'D) bag. The rock boxes and so on were in the extra decontamination bags. I thought the command module was remarkably clean. It was a lot cleaner than I had expected it to be.

ROOSA I thought it was exceptionally clean. When you passed the suits over to me, they were dirty, but they weren't dusty. In other words, there was no loose dust coming off the suits. The only dust that came off was when as I was shoving them into the bag; but that was a contact thing. There was nothing floating free at all from the suits.

SHEPARD We felt the procedures that were suggested, perhaps by Apollo 12, and carried out in our time line, certainly reduced the dust to a minimum. Can you think of anything from the LM side that was confusing?

MITCHELL The only thing that resulted in a bit of confusion was on page 15 of the checklist. We were fairly well into it when we got the LM/CM weights, which is actually item number 2 on that page. Not wanting to break my continuity of procedure at that point, I just wrote them down and went on. I did not go back and reload the PGNS at that time. When we eventually came to reactivating the LM for jettison, those new weights had not been loaded in the DAP. Ground had to notify us that we were getting some unnecessary firings out of it. I don't

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MITCHELL really have a suggestion without thinking about it a little
(CONT'D) bit more. Either I should have had the information earlier,
or we should move that block down so it doesn't upset the
continuity.

ROOSA Didn't you get that as soon as we docked?

MITCHELL Well, in reading this over, I tend to agree with you. In real
time, it seemed to me that I was already past that point in my
checklist when those came up. So, before I say anything else
about it, let me read through the transcripts again and see
just exactly how that went. Anyhow there was a bit of confu-
sion there and I think it might have been my fault.

SHEPARD Yes, it's written down here, and as Ed points out, it's pro-
grammed to be put in there right at docking where 144:12 is
the correlated time. But the point of the matter is that both
the MODE CONTROL switches go off at docking, and they don't
come back on again until near 145:50. So, it's kind of super-
fluous to load the DAP at that particular time.

MITCHELL In any event, there was some bit of confusion. In my mind, it
didn't seem appropriate to be doing that at that time, and for
the life of me, I can't remember just exactly why.

SHEPARD We may have an LOS problem here, but I don't think so.

[REDACTED]

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ROOSA I distinctly remember getting that DAP load, because I said yes. They were bugging me about my weight prior to docking, and I didn't want to change it then because I was going to change it after docking. But they called so many times that I changed it during the loop. As soon as we docked, here came a weight that was actually different from what I had loaded. I reloaded it again at that point. It seemed that as soon as we got the hard dock, we had a new DAP.

MITCHELL Yes. Reading through the transcript confirms what you said, Stu, and conflicts with what I had in mind. So I'll just have to think about it and see what was wrong there.

SHEPARD Nothing was wrong. They were going right by our time line. It says configure the PGNS. We needed the DAP load from MSFN, and they were going right by our time line. It's obviously in the wrong place.

We've already commented, in general, on the decontamination bag. The procedures for vacuuming and the decontamination bags worked out fine.

ROOSA I think a lot of the credit on the way the stowage went over has got to go back to Dell'Osso, again. He really had this figured out. We all went through this together one time over

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ROOSA (CONT'D) the Christmas holidays, but Ray has gone over the Command Module side with me at least twice in addition to that. He made sure I was organized on the equipment as this is an extremely tight time line. There's very little room to be fiddling around from the time that you dock until you come up to jettison. I thought Ray did a magnificent job.

SHEPARD All the men involved in this effort — Dave Schultz, Jim Ellis, Scott Millican, Ray Dell'Osso, Terry Neil — they are all to be commended for their efficient training.

We even had time to get a few extra goodies out of the LM during the transfer. Most of these went into a B-4 bag that's officially known as the ISA.

MITCHELL As I recall, we were within a couple of minutes of the programmed times as we turned the page and came on down here.

SHEPARD Which, I guess, means it's a fairly good time line since we had time to remove a few extras from the spacecraft. Got both of them. After we closed the command module hatch and just about 2 minutes before jettison you said, "Hey, did we do this?"

MITCHELL Well, I had been going down the checklist and I had marked a slash by every item as I did it. After we got into the command module, I was reviewing that to make sure that everything had

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been completed. Just before jettison, I got to the bottom of the page and the only thing that had not been marked was verify uplink data. Now, they had access to the computer before, and I was reasonably sure that the data switch was in the DATA position, but that particular item, number 6 on page 16, did not have a check mark by it. I had a moment of sheer terror right there that we were going to let the LM go with the updata switch off and they wouldn't be able to get into it. As it turned out, it had been accomplished, but I had not checked that one off.

SHEPARD

We transferred some extra items that were requested by the ground in connection with the tying down of the probe: the 100-foot tether, the waist tether, and the webbing, in addition to the Hasselblad and the EVA gloves which we talked about before. I never did figure out what they wanted that waist tether for. We never did use that.

ROOSA

I think they wanted one for the probe. We used all of the normal entry tiedown ropes on the probe, so we needed some for the PGA on the right side and one to tie down the PGA bag. I think that's what they were thinking there.

MITCHELL

Well, the impression that I had as we came into this final part, was that when these items were requested, the final

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MITCHELL (CONT'D) stowage in the command module had not been simulated here and people wanted plenty of tiedown material in case we needed it. We ran out of the webbing, and then we used the EVT line. We never used the 100 feet of tether but we did use the waist tether. I don't remember how much of it we used, but we used some of it.

ROOSA Well, how long is the waist tether?

MITCHELL It's about 20 feet long.

ROOSA That's the one we used on the PGA bag.

SHEPARD Part of that webbing was used to tie down the support arm of the probe.

ROOSA We used the bulk of it, though, on the PGA.

MITCHELL We had to rush to stay on the time line. That went very smoothly.

I might add one more comment. Due to the fact that Stu was doing some things in the command module while we were doing other things from the LM, the coordination was not absolutely perfect. I didn't want to stand around and wait while he was doing something. I proceeded on with different portions of the checklist. This makes it absolutely mandatory that you

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MITCHELL mark off each item because if you skip around with the check-
(CONT'D) list at all, which I did in order to get everything done, you're
going to leave something out if you don't mark it.

ROOSA You seem to imply that we had more time there than we did.
We barely made the time line. We didn't have enough time to
completely wait out the full time on that hatch integrity
check, if I remember right. That was sort of a hangup: the
10 minutes that you're supposed to wait.

SHEPARD That's right. We were venting down a couple of minutes late
on that.

MITCHELL Except, I think we closed the hatch right on time, didn't we,
Stu?

ROOSA There was no pad in that time line. We finally made our time
but you've got to be ready for it.

MITCHELL As Stu says, we did make it, but there wasn't any extra time
in it at all.

ROOSA Won't they have a bigger load of rocks in subsequent missions,
because of the Lunar Rover? It'll take them longer to get
those transferred.

SHEPARD We didn't put down the time in which the tunnel was closed,
did we?

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MITCHELL You were hollering at me that we had 5 minutes to get the tunnel closed up, when I started to come through. And, it was within a minute or two of the time line time.

SHEPARD It was very tight. There was no loose time in there at all. According to the plan, we were supposed to bleed down the tunnel for 10 minutes prior to jettison, and I was up in there doing that. Seems to me, we had decided that it would be less than that. We said, "Well, we've got about 2-1/2 to 3 minutes to go. I felt that there definitely was some pressure in the tunnel at the time that we jettisoned. Now, what the pressure was, I don't know, because you've got to switch position to that valve in order to read up the pressure and then put it back in the vent position. The last reading was something like 3.3, 3.1, 3.3 or something like that. Then it went on back into vent position for a minute, so the chances are that we probably had a DELTA-P of about 1.

MITCHELL No, I don't think so, Al. I didn't write them down — but you didn't get it down to the needle peg as it called for, but then you just put it in vent and we said, "Look, we've got so much time prior to the burn." It was time for you to get out of the tunnel. So you just went to vent and left it.

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SHEPARD I left it, but I took a reading before I did that and it was something like 3, 3.1, 3.3. That means that we didn't get it down to zero. We had somewhere around 1.0, I'd say, by the time that thing finally let go. So, there was some DELTA-V recorded as a result of that. I'd say about 1 psi.

MITCHELL I bet you it wasn't that much.

SHEPARD Anyway, it wasn't zero. So, that should have been started a little bit early. But it apparently didn't perturbate the FOD guys very much.

MITCHELL That jettison was so smooth you can't believe it. I was watching the LM through the COAS on the docking target. You hit the jettison and the LM sat right in the target and just moved away. There was absolutely no perturbation on either vehicle. The LM just backed off and the docking target and everything else were still lined up. And it was just moving away from me.

ROOSA It was steady as a rock out my way.

SPEAKER Docking in reverse?

MITCHELL It really was. Like running the camera backwards.

SHEPARD We had no problems with jettison separation. We did a P52 and torqued and a GDC aline. Apparently everything went along very well.

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ROOSA A comment back on the jettison SEP. I just stayed right in the same attitude, and 5 minutes later did the SEP burn. It's a 1-ft/sec burn. I did a three-axis rather than go into a pitch maneuver or anything like that. And it worked out real well. As it turned out, you had 0.8 of that 1 foot in the Y-axis. So, basically it was a one-axis maneuver, but it really worked out smooth — just staying right in the same attitude, going back in to P41, and pressing right on in and doing the SEP burn rather than trying a manual pitch or anything like that in that time frame.

SHEPARD Yes, you probably save gas in the long run.

ROOSA Yes, it was just the procedures of it. I think everybody's going to do it the way they want to anyway, but these procedures were pretty good.

SHEPARD Okay, we had some updates here on the 500-mm lens.

MITCHELL We had originally planned on taking some Hycon pictures, on the REV just prior to TEI, of the S-IVB impact. Everybody has asked us if we were sure we wanted to do that during that busy time period and we said we did. However, when the Hycon camera broke, and we decided that it wasn't working; we had eliminated picture taking from our minds. We hadn't planned on it, and

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MITCHELL (CONT'D) it was stowed. I would have left the Hycon box open if we had planned on doing this. Then they passed up the procedures to use the 500-mm lens to take the S-IVB impact. That was really a call beyond duty at that point. I had the 500-mm lens and brackets stowed and everything out of the way when that call came up. We did it and the pictures look good. I hope they're in the area where the S-IVB is. They just told me to aim on the northeast corner of Lansburg B, and that's where I shot. I hope the impact point is in that. We were getting awfully tired at that point. That was a pretty good effort to get all that stuff unstowed and up for those pictures. I think it's just a case of, at the end of a long day, doing something you hadn't really planned on. You know, we were all for getting the S-IVB pictures, but that's when we had planned to do it.

SHEPARD Yes, I guess the message is that's a bad time to update anything that's a major departure from what your flight plan says.

MITCHELL Because you are tired.

ROOSA Going into the docking, I had the command module stowed just as thoroughly as I could, because I knew we were going to be getting a lot of stuff back.

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SHEPARD The next item was the TEI burn. We got into P40 all right. I think there was plenty of time for MSFN to look at it before we had LOS there.

ROOSA Twice. We went to P40 once to make sure they saw it. Then we had to go do the maneuver and so forth and then we got into P40 again, before we went LOS. So they really saw P40 twice.

SHEPARD Okay. I don't believe we had any real problems with the TEI burn.

ROOSA There was a little vibration at the end of it.

SHEPARD We had some discussion about a buzz in connection with the SPS burn earlier, which I thought I noticed. But neither one of the other two guys said anything about it though. Stu mentioned something about a small, barely perceptible hum or buzz toward the end of the burn.

ROOSA Yes, it was about 20 seconds to the end of the TEI burn. There was a definite buzz in the SPS. It wasn't there before.

SHEPARD Anyway, it didn't seem to be anything off-nominal as far as I could tell about that burn, in comparing DELTA-V time, for example, with the DSKY readouts of the DELTA-V. Operating, the engine seemed to be real good all the way through.

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ROOSA Beautiful burn. How else could it be?

SHEPARD We had the residuals at cutoff of plus 0.6, plus 0.8, and minus 0.1. Then we trimmed to plus 0.2, plus 0.8, minus 0.1 per flight plan. It was just a good burn. We then came around and maneuvered to the photographic sequence attitude. That is the attitude for taking pictures of the departing Moon. And as everybody else has said, it really is a sight to see that Moon shrinking. Everybody had a view out of the windows. We moved back and forth looking out each other's windows. Ed and Stu were manning the cameras. I don't think we had any problems during the photographic sequence.

ROOSA I saw my one and only earthrise. It came right up, out of my window.

MITCHELL It was just a slim sliver of the Earth on our flight. It wasn't very large just prior to PDI. While we were over in the LM, it was fairly nice. It was the best one we saw.

SHEPARD On our second pass, I guess about all we were capable of doing was taking pictures. I had the feeling that all three of us were as tired at that point as we had been during the flight.

ROOSA Well, I don't think there's any doubt about that. I think we were wiped out.

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QUERY Did you have any comment about PUGS operation?

ROOSA The PUGS were absolutely nominal. Of course, change-over had already occurred on LOI. So, during TEI, it was just a matter of controlling it in the green band, which I did. I think it took one or two movements of the valve to keep it where I wanted it. No problems.

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14.0 TRANSEARTH COAST

SHEPARD We indicated here that we all slept fairly well. A general comment is that the day after TEI, we were still not up to full speed as far as I was concerned. We seemed to have trouble getting ourselves into the flight plan. We didn't miss anything big. We really didn't have any big items but the little things seemed to keep missing. At the time, I thought that was the day which was the roughest of the total mission. At other times, we were pretty well on the time line, but somehow that first day after TEI, it seems that we just never did get hold of ourselves for some reason. I think it was because we were still loggy from the day before. It is always embarrassing to have someone from the ground call your attention to an item already in the flight plan that you should have picked up. Here again, there are always little items missed, but it's still an indication that we probably weren't functioning at maximum efficiency.

There was nothing abnormal concerning the postsleep checklist, except on something as simple as a canister change. It looks like we were an hour and 40 minutes late.

There was one comment we made at the end of that day. On this particular flight plan, the P23 information was incorporated.

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There are other things going on in the flight plan simultaneously, so that we ended up in a situation where Stu was down in the LEB, and Ed and I were floating around elsewhere in the spacecraft. The flight plan was floating around with us, and I think that turned out to be part of our problem. There was no one checking off the items in the flight plan to be sure that we got them done. In the future, maybe the best thing to do is to break up P23 information into a separate book, so that the guys working the P23 open loop can go ahead and do that. Whereas, the rest of the flight plan can be checked off by the other guys not involved in the P23s, or at least superficially involved in the P23.

ROOSA

Yes. I think they ought to be in the flight plan just as they are shown here if people are going to run a whole series like we did. But these same sheets ought to also be, say in the back of the solo book.

It seemed like I started a P23, and then they would want to have a flight plan update. So, then we'd have a shuffling of the flight plan around or have them stand by or something like that. So, you should have the transearth coast P23 listed on some separate pages in whatever book you put them. It's a dealers choice.

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MITCHELL The P23 takes up such a major portion of your time when everybody else needs the book.

ROOSA There's quite a few hours in which you are tying up the flight plan on a P23, during which, nobody else can handily look at it. We passed it back and forth, but it's not a good arrangement.

SHEPARD There was also something else going on at the same time. We were trying to run some of the inflight experiments. This wasn't the first day after TEI; this was the following day. But that was another thing which required time sharing of the flight plan. You really had three things going on, the P23, the experiments, and the cooking of these metal samples, in addition to the normal routine functions of the spacecraft. They were all in the flight plan, so there we were.

ROOSA The tabs on F-1 and F-2 compartments stick up in the plus-X direction. They would get hung up when you're trying to get into compartments R-2 and R-3 in that area. These tabs were always in the way. I see no reason why they can't be rotated 180 degrees and pulled from the bottom. This is just a minor item. Another item on the B-3 cushion: the 10-mm and 75-mm lens kept floating out. Every time you pull that cushion out,

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those two lenses would come floating out. They just weren't stuck in the cushion hard enough.

SHEPARD

The helmet bags have four straps placed at 90 degrees around the bag. Each bag has a snap on one end, and the other end goes through adjustable rings where you loop through the rings and tighten it down. Normally, all you do is to just snap one of these babies on a snap on the bulkhead shelf or wherever you want to snap it. The others just came loose in the area, and you'd find these helmet-bag straps floating around all the time. So, there ought to be a better friction device to keep the straps from unraveling themselves and sliding out through those two keeper rings. They were floating around. The idea is fine. It works, except there's just not enough friction on them.

MITCHELL

The other three that aren't being used always float away.

ROOSA

I would like to comment on the P23s at this point. As everyone knows, basically I was trying to run a no-comm series of P23s all the way back. These were fitted in not at the exact time as you would shoot them on an actual no-comm situation with the exception of those you would take right after TEI. I think the total number was the same even though we shuffled them around a little bit because of that CRYO DTO and the rest

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ROOSA
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periods. We kept the state vector that we burned TEI on. We did not update it, and the next day we started shooting P23s on that vector. This was sort of a worst-case condition. You had loss of comm, but you didn't get in the post TEI sighting, and so at that point, we started hammering in the P23s. I guess there's nothing much else to talk about techniques. Everybody will work that out for themselves. I did, I think, in planning, make one mistake. I agreed to shooting constraint stars as well as stars that I would use for navigation. This essentially doubled the amount of sighting that you have to take, and that's just too many. By the time you get down to entry, you just had too many P23 sightings. I think if you're going to run a no-comm case, I'd shoot the stars needed for navigation. I wouldn't shoot the constraint stars. It just made too many sightings. To do P23s takes a good bit of mental concentration and a good bit of effort on the minimum impulse controller. And you just flat get tired of shooting those constraint stars. The state vector, I think, came hammering in and stayed pretty well.

As we came down on the last day, the P23 state vector was in great shape and then converged, and I understand we were 0.0 something off in gamma and 0.5 mile in perigee or something like that. Then I screwed it up on the next to the last two

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sightings that you do on P23. I switched from the Earth to the Moon horizon, and, during those series, I screwed the thing up. I blew the state vector as the result of several things. When I shifted bodies from the Earth to the Moon, I was expecting a big update, and the other one was that I misread the damn decimal point. Al gave me a little help in there, but it was my ball game, and I screwed it up. So, I got some bad updates into the state vector there. I think we did show that P23 was a pretty good program and can bring you home with a good state vector. I think we also showed one of the pitfalls: when you do switch to the Moon, you've got the possibility of getting the wrong horizon. You have to just pay a little bit more attention to it. I felt real bad about that. I had put in a lot of work on those P23s and had taken a lot of sightings. I sure wished that hadn't happened, but it was a screwup.

SHEPARD

As far as I'm concerned, it's a hell of a blow for freedom. I think Stu put a lot of work in on this thing, and results certainly show it.

I noticed that the recycle is a bad move because of the number of keypunches required for recycle. Certainly there ought to be the ability to reject the mark. That's consistent

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SHEPARD
(CONT'D)

with the ability to reject marks in P52 and 57. There's a way that the keypunching operation can be cleaned up a little bit. But as far as I'm concerned, it's a hell of a fine demonstration that this kind of a program in onboard navigation will in fact work. It can be cleaned up a little bit, but it's a damn fine program.

ROOSA

That recycling is much worse than what it sounds at first count. The number — 1, 2, 3, 4, 5, 6 — it takes you some 6 strokes in waiting for a couple of comp cycles to get back for your next sighting. And the way you're working in minimum impulse you can never stop the vehicle cold on the way home. You're too light. So you get it down to the substellar point and you've worked it down. In many cases, you don't have a landmark that you can pick out and bring the star back to. Many times you're having to fight the spacecraft back to the substellar point again and again. So you get it there, then you accept the mark, and then recycle back to where you're ready to mark again. You have to go through this half a dozen DSKY operations and a couple of computation times while it has to recompute its attitude again and flash you the option for the maneuver and so forth. By then you've drifted off again and now you've got to bring it back. It's really

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ROOSA (CONT'D) troublesome. You really need just a fast ACCEPT on the mark, and then a fast VERB 32 or something to bring you right back down to the flashing 51 again. It would really aid the operation.

MITCHELL Well, the program as currently designed only allows you one mark for a series. Right?

ROOSA That's right.

MITCHELL What you're really saying is that, if we're going to do more marks, we ought to be able to make more marks without going through the whole program.

ROOSA That's right. I guess the only other thing on P23s, as I mentioned before, would be if they get the slide in the CMS — I think they're working on them right now — it will be an aid. It was an interesting exercise and it took a lot of work. I surely do feel bad about those sightings at the end.

SHEPARD I think it's the kind of thing that you can make operational. We have, for example, ground rules on NOUN 49s when you're updating. You've worked with it in training, and you just get to the point where you just recognize that one of those that's out of the ball park was a state vector that was displaced because of sync malfunction or something. And you

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SHEPARD
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recognize them and you just get in the habit of not accepting them. The same philosophy could apply to the P23s. I think it was a damn fine demonstration myself. I'm glad it came out the way it did.

We got to the point where we had a DTO on CRYO O₂ flow, and that got updated. They started a little bit early and that got us a little bit confused. I'm not sure that but what we didn't foul up a little bit on that one.

MITCHELL We only ran it for an hour instead of — what was it — 2 hours or something?

SHEPARD No. We ran it for an hour but I think, didn't we find that we had panel 251 open?

MITCHELL If so, that came as an analysis later, Al. There's a discussion about that but I don't know that we ever verified that.

ROOSA I know we used Myrtle during that period of time.

SHEPARD Yes. That was one thing that I guess we were a little surprised about. None of us could remember being briefed as to whether or not we should make a urine dump during that time period or not. And the test was terminated early. We'll probably find out specifically why during our Systems Debriefing. But, in looking back at it we said to ourselves

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"Well, have we ever been briefed in any discussions of this DTO whether or not we should have been venting through Myrtle or not"? None of us could remember having been. So, if that were the case, if we're not supposed to make any other vents, then it wasn't obvious.

ROOSA

If we left Myrtle open that was a mistake on our part. Whether or not that would jeopardize the test, I don't believe we had ever been told. We were on and off with that fool vent on Myrtle for various and sundry reasons. The P23s and trying to update the flight plan to run the CRYO DTO — you know the flight plan was back and forth — and I'm sure that added to the confusion here.

MITCHELL

We moved the beginning of the setup for the test to coincide with your P23, and the flight plan was being shuffled all around at that point with updates, etc. It was a little bit confusing, certainly to me.

SHEPARD

I think it was, because we were questioned about the position of the circuit breaker later on during the test and it wasn't immediately obvious what had happened to it. So, it was a confusing period there. But anyway, the test ran for an hour and I hope that the requirements of the DTO were fulfilled.

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[REDACTED]

SHEPARD (CONT'D) But it was a little shoddy, I thought, at least from our point of view. We didn't feel like we were, on top of the thing all the time.

SHEPARD Talking about transearth coast, one of the systems that we used was the urine dump system. In general, I think that Myrtle worked well. There were two problems: first off, I think we're pretty well agreed that it was not getting any PTC as soon as we expected because of the docking problem.

ROOSA That's the way it appeared to us. I don't know what they had advertised as the capability of those heaters. I don't know whether our heaters were up to the normal capacity or whether they can't hack a long attitude on the dark side. I guess we're convinced we froze up at least twice.

MITCHELL Yes, it's significant to point out that it didn't take long being in the Sun or being in PTC until it thawed right out. So in my opinion, the freezing had to be very near the end of the line. As soon as we got back in the Sun, it melted right away.

ROOSA We tried to troubleshoot it a little bit, but that's a tough system. It's either working or it's not working. We tried to switch the heater. We thought maybe we had a filter clogged, so we switched filters. I don't think either one of those

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actions solved the problem. I think the problem was solved when we got a little sunlight on it. When the heater freezes up, you build up pressure in the line. I guess, from the outgassing of the urine particles that are in that line, it builds up pressure and will just blow the top right off of Myrtle. That happened two or three times.

MITCHELL

I suspect that, when it clogs up, the residual heat in the spacecraft expands the gas inside that urine system and blows the lid. Early in the flight, when we didn't really know the answer, we convinced ourselves that maybe the filters were clogging up. So we established a procedure of keeping that system flushed. We used an awful lot of water flushing that system out to make sure it was clean all the time. When it initially froze up, we thought it might be the clogging of the filter. So that brought that home to us very strongly. From then on we didn't take any chances with it; we flushed it all the time.

SHEPARD

It's probably just a matter of being familiar with the system recognizing the pitfalls. From the standpoint of hardware, the little switch in the top of Myrtle, with the vent closed position, has not too much friction on it. It also has a string that is tied to the bottom of the receptacle to keep the top of the receptacle from floating away. That string is

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... tied to the handle and would get wrapped around. The practice of leaving the panel vent open and the receptacle vent closed was the mode we operated in during the day. And, that little vent on the top of the receptacle would get open halfway and we would be venting and didn't know it. So a more positive stop, I think, would prevent that, plus detaching that lanyard from the handle and also somehow drilling a hole and putting a fitting on the top itself so that the action of the lanyard and vent valve can be separate. Outside of those things, if a guy is familiar with the system, it works fine. There was a little spillage. Of course you must have a little tissue around.

ROOSA

Yes, I think leaving the overboard vent open all the time during the wake period helped out quite a bit. Like previous flights, we had less urine floating around when you took the cap off and so forth. That's probably a good procedure — like you say — fix that little dial.

SHEPARD

That's about all there was on that day, I guess. At the start of the following day at 186 hours, we went through the usual wakeup routine, updates, and so on. Generally, what had been planned for the TV shows — this was kind of Stu's idea to start with a long time ago — was that there should be something different on TV shows besides the astronauts floating

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around upside down and throwing pencils back and forth. So, as a result of a lot of effort in the interim period, four experiments were proposed, and we felt that a couple of these ought to be usable on television. I think it turned out that this is probably the case. I'm sorry to hear that this wasn't picked up too much by the networks, but apparently, as far as the control center people are concerned, they were very interesting experiments. I didn't feel that that really taxed us too much. Other people did all the work on that. They had all the scripts written and all the good words and everything else. Obviously, we trained with them, they had some training equipment down at the Cape that we went through a couple of times. They were very straightforward, foolproof techniques, and I thought that that was a very worthwhile show. I'm not sure that the press treated it the same way. Originally, we felt that these were the kinds of things that might be able to do us some good. I guess time will tell what the response to that was. It did not detract from the time line. It was a quiet time period. Procedures and equipment were in such good shape that we found that it was easy to accomplish these experiments within the time line of the flight plan.

Here are the notes on the heat flow. We just went down the checklist and photographed it as we were supposed to. And

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the anomaly we noticed here was where Krytox fluid that was supposed to go into the cup and flow evenly over the bottom of the cup (that is, the side of the cup toward the instrument, the heating panel) didn't work that way. It flowed very nicely over the bottom of the cup in one g, but it sure didn't in zero. It made a beautiful fillet, because of its surface tension, I guess, the difference in surface tension between the sides of the cup and the bottom. And we ended up with a bubbly Krytox fluid that had a beautiful symmetrical fillet and went right up the sides of the thing. We photographed it that way. We made an attempt with our finger to put the fluid down in the heating element at the bottom part of the cup and some of it stayed, but we never did get any real good Benard cells development like we had gotten on the one g stuff.

MITCHELL We saw the movie film of that last night. It shows that phenomenon very dramatically.

SHEPARD Will they show the cells?

MITCHELL I don't know.

ROSSA No. I looked for that. I didn't see the cells.

MITCHELL However, we were running the film backwards since they recorded the damn thing on the roll backwards so we might just have missed it.

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ROOSA I guess on that Krytox, there were far too many bubbles in the fluid. Now, if they are going to run this again, they ought to have some way to insure that you don't have the bubbles in the fluid. I don't think that was the basic problem. The basic problem was that it wanted to go on the sides and not on the flat surface on our plate. But I know there were too many bubbles in it, and I guess maybe a miscalculation on the surface tension kept it from flowing out properly.

SHEPARD Other than that, the experiment seemed to work very well. And it's been photographically documented.

ROOSA Yes, the photographs I saw last night of the crystals looked real good. The focus is good and it's clear, so they should get all the data off of that one with the exception of the Krytox. I think they were anticipating trouble with that anyway, because our procedures said, try twice and if it doesn't cling to the surface, stuff it full of tissue and quit. So, I think there was probably some question on that.

SHEPARD We tried it three times.

ROOSA Oh, we tried it four or five times. We gave it a good show, and it just wouldn't work.

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SHEPARD Concerning metal composites, there's not too much to talk about procedurally on that, either. It was a very simple procedure. It was time consuming, and it could only be done with no jets firing so it was pretty much restricted to the PTC time line. We did samples 1 through 12, excluding 3. And, the reason we didn't do more was that there just wasn't time. I have only one comment; during number 12, a small number of jet firings occurred about halfway through the cooling cycle. Other than that, we felt the procedures were followed to the letter. Do you have any comment on that?

ROOŠA Well, as far as the jet firings, we knew that one was going to happen. Actually, we knew we didn't have time to cool it before we came out of PTC and we said, "Well, let's just give a data point on what happens when you fire them." Because it was either that or not do it. We just didn't have enough time to ... I guess the only recommendation you could make is — if you have that many to do, and you're going to be out of PTC as much as we were coming home — you should concentrate more on it going out, but we did, we tried, we were aware that we ought to get going on that, and I just don't think we had enough time to do that many and be restricted to PTC.

SHEPARD If I may make a comment on this thing. I think we had enough samples that we did according to protocol that we ought to be

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able to tell from the data whether or not it's worthwhile to continue this kind of experiment.

We did just like we were supposed to do on the liquid transfer procedures. We pumped the fluid, took pictures, and did it on television. By the time we got down to the actual picture taking, we had a few more bubbles in the fluid than we had earlier so the video tape probably will document that as well as the film.

ROOSA

The film looks good, but it does have the bubbles in it that Al mentioned. Hopefully, they can cut some tapes of the initial transfers that we did on TV.

SHEPARD

We could see the flow patterns. That thing was pretty spectacular. It worked real well.

ROOSA

It shows the importance of baffles; you can't work that fluid without it.

SHEPARD

We lost a little fluid when we first opened it up. That was due to internal pressure, I guess.

ROOSA

The last of the four experiments was the electrophoresis. This is the organic experiment, and as far as I can tell, it was an abject failure unless somebody can see something on the film that we couldn't see. We started the red and green dyes,

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and instead of coming out in bands, they came out in a very thin streak and moved across. That was the only action that we saw. We saw nothing out of cell 2, and they said that we probably wouldn't see anything in cell 1, but would have to take it on the film. We ran through the procedures just as shown, and Ed documented extremely well what happened in cell 3 where the red and green dyes were. We took all the pictures by the book, but I'm a little leary about this experiment as to whether or not we got anything.

MITCHELL

I'm a little leary about the photographic documentation as well because the red and green colors were so darn faint we could barely see them with our eyes. I don't have any hope that it came out on the film either.

ROOSA

Yes, I have doubts about whether the film will show the dye, but you've got that. And hopefully, the films will show if anything happened in cell 1 with the infrared light behind it. We took the high-speed film of it, and if there was anything happening, it was there. But I'm a little leary about the whole experiment, and I'm disappointed too, because I thought this probably had the greatest hope of being a significant breakthrough in something. I'm discouraged about it.

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SHEPARD So that brings us back to the flight plan at 186 hours. You had a comment about the optics panel test.

ROOSA Yes. I have a comment about the test switch on the optics panel to test the lights. In the TEST position, the only light that would come on was the MASTER ALARM. It wouldn't test my other warning lights on the optics panel.

MITCHELL Was that only at that point in time?

ROOSA No, this was through the whole flight. I finally made a note of it here to remind me of it.

SHEPARD That was when we did a VERB 35 later on.

ROOSA The PGNS light would come on when we'd get an alarm code so the lights themselves worked, but not with the test switch.

SHEPARD We had a press conference TV show at 195:30. We had agreed upon this ahead of time, assuming everything else was going along well. And everything else was going along well so we went ahead and did it. The comment was that it wasn't any problem to us. It was at a time during the time line when it was not difficult to fit it in.

MITCHELL Except, as I recall, it was a little rushed at that point because we were busy tying down the probe or something.

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SHEPARD Yes, but we had it tied down to the point where it wasn't going to float away during the TV show.

ROOSA But the press conference is something that takes zero preparation. As it turned out, we taped the camera down to the headrest on the center couch, and according to the monitor, it looked like we were in a good spot. So you don't really have any preparation to do other than get the camera out.

MITCHELL The technique we discovered in flight, which I don't think had ever been mentioned, but obviously somebody had thought of it beforehand, was to Velcro the monitor onto the television. If the guy who is running the television has them right together, he can watch the monitor while he's working. In the case of the press conference, we just turned the monitor around so that we could see it and still be on camera, and kind of gage what was going on. It worked very well that way.

SHEPARD Well, it's the kind of thing I think ought to be a real-time decision if everything is going along well otherwise. It's okay to go ahead and do it. I sure would hate to commit to that ahead of time though, because you could be screwed up with some other problem in the flight and you'd just be happy to be on the way home and wouldn't want to talk about it.

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SHEPARD (CONT'D) On the darkside, dimlight photography, the same comments apply as on the way up. There was light scattering in the lens with the LM on.

There were the usual updates and postsleep reports and more P23s.

ROOSA They did have us close the potable tank inlet at this point?

SHEPARD Yes. They had updated the night before that they wanted us to close off the potable tank inlet so it would help the L/D.

ROOSA I've got to find out in my systems debriefing how much that changed.

SHEPARD Anyway, we thought that it was a good call since the L/D was going in the right direction.

MITCHELL Getting that close with it means you might have to slide down a little bit further on the couch if you haven't used Myrtle in the last few hours.

SHEPARD Okay. We didn't say anything about the midcourse. We went right on by it. I guess it is hardly worthwhile talking about. It was 0.7 ft/sec RCS, and that was done, and that was it. But that is fantastic when you consider that that was the only midcourse all the way from TEI to entry interface. Beautiful.

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ROOSA And with the JETTISON and SEP for the LM modeled in the TEI burn. The time line seemed to be good the last day. We didn't seem to have any real problems that we've noted down here.

I would like to comment on the boresight star Nu Hydra. I don't know where they came up with it, but Alhena was a much better star. Nu Hydra wasn't even in the window unless I scooted my head way down.

SHEPARD We couldn't figure out the boresight star for the entry attitude. We couldn't figure out why they used that particular one unless they were trying to pick one that was so obscure that nobody had ever heard of it.

ROOSA By their own data, it was up 22 degrees from the center of the COAS. That put it out of the window.

SHEPARD Anyway, it passed the sextant star check.

ROOSA If you're going to have a boresight star you might as well have a good one.

SHEPARD I didn't feel rushed or behind our schedule on entry day. We just kept working away right on down our time line and actually ended up ahead most of the time. We had the additional items for stowage which we had taken the day before. We took

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SHEPARD (CONT'D) care of most of our stowage the night before. We stayed up real late to do that and just had the peripheral items for stowage on the morning of entry day. After we awakened, which was readily accomplished, we were in real great shape for the entry. We weren't rushed at all.

ROOSA That's quite a bit on entry.

SHEPARD The point being is that it took some preplanning to do it.

ROOSA Yes, it did.

SHEPARD I felt we were in pretty good shape. It was all that preplanning. Did we ever decide whether we had a leak in the REPRESS pump or not.

MITCHELL In my mind, we did. It leaked down about three times and at least three times we pumped it up.

ROOSA I remember pumping it up twice. Our REPRESS package did go down. The first time I noticed it, I was by myself in lunar orbit. I pumped it up and never got around to calling the ground on that one. We pumped it up once on the way back. And we may have had a slight leak in it.

MITCHELL You pumped it up once in lunar orbit, and I participated in two pump-ups. One time, we brought it up to the bottom of

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[REDACTED]

MITCHELL the green band, and then on entry, we pumped it up again. It
(CONT'D) was below the green a little bit. We brought it clear up to
the middle of the green band.

ROOSA So it was three times.

We had very little condensation. The only time that we had any water condensation in the tunnel area was when we had it packed full of the rock bags, the probe, and so forth. The air was not circulating, up there. Once we had the tunnel half way clear we had no condensation. As we mentioned before, we had zero dust.

SHEPARD Yes. This was the temporary storage locations for those bags. To keep the sleep areas clear at night, we'd run those babies up there to get them out of the way. When the tunnel was checked before entry, there was a thin film of condensation. We had no problem with updates. The entry attitudes were no problem.

ROOSA We went to the entry attitude; you did the star check; and then you received a certified copy of the P52.

Then we maneuvered up to the horizon-check attitude at 267 degrees. We had a dark horizon which didn't bother us

[REDACTED]

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ROOSA much. We didn't get the horizon check but I never considered
(CONT'D) that a big deal.

MITCHELL Let me make one comment on updates. On the entry pad we re-
 ceived, both in simulation and in flight, a large number of
 additional comments. There's just no place to write them on
 the update pad except along the margins. We ought to make
 some provisions for that.

ROOSA I think somebody should take a look at revamping that entry
 pad since there's so much more data on it now.

We had no horizon check, and we were riding about 10 or
15 minutes ahead of our time line at the average g point.
From then on we stayed right smack dab on the time. At minus
30 minutes, the main bus ties were brought on right on time.
It was difficult to hear the CM RCS thrusters fire. After
SEP, they were easy to hear. On the first ring that we
checked, we went around it twice, and I really couldn't verify
that I had heard every thruster.

MITCHELL I think we finally verified by looking out and seeing the
 particles fly by the windows.

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[REDACTED]

ROOSA You could see some of the thrusters fire. Then the ground called and said that the ring looked good. I think the retros probably want you to use just as little fuel as possible because they've got that taken into account on their L/D.

[REDACTED]

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15.0 ENTRY

ROOSA SEP was a great experience. Everything transferred. Everything was backed up per the checklist. Flying the vehicle manually was great. I had flown the CSM manually. I went to one ring minimum impulse and it was a little less responsive, I thought, than the CMS. It was very close. The CMS is extremely good, but a little easier to hold your attitude than the CM. We pitched down, picked up the Moon, and about this time we did see the horizon. We were watching the horizon and watching the Moon come down toward it. I called moonset. My call over the air may have been 2 or 3 seconds early. Let me mention that both EMS checks went extremely well. The one at EI minus 30 hours was real fine, and the one as we approached EI also looked good. As we approached 0.5g, everything was nominal. I was not far off my 154 degrees watching the moonset. Around 154 degrees, I started watching the time come up for 0.5g and started picking up the ionization. She started turning red outside a little sooner than what I expected it to. As we hit 0.5g, Al called switch to P64. The way we had practiced this worked pretty good on the entry. Jon Harpold gave me excellent instructions, and Al, Ed, and I had coordinated real well in the CMS. I thought we really had the entry down pat. I waited my 3 seconds. I

CONFIDENTIALROOSA
(CONT'D)

didn't get EMS started. I went back up, and then EMS rolled 0.5g. Then coming off of peak, Al would call out the DSKY roll commands. I'd be sitting there waiting. We'd all discuss the time to roll liftdown as we approached 5g's. It rolled right on time. We went right on through the entry just like in the simulators. It wants to dig in a little bit too much, and it kicks off a little more potential than you like to see, but that's the G&N entry. We came out of blackout and had good comm. Just prior to entry interface, the comm was beautiful. After blackout, I heard Bruce loud and clear. I don't know how our transmissions came through to the control center, but it was good in the cockpit. All the way through, the EMS and G&N were checking very close. I called that to Houston after blackout. The transonic region has been mentioned before and it's simulated well.

MITCHELL The steam pressure peg was somewhere between 5 and 10 seconds late. I was more interested in watching the steam press gage than the time point. At 636 it still had not started to move up so I switched to secondary. It hadn't moved either, and I remarked about it to Al. About that time, it started to move. I don't know exactly where the steam press pegged, but it was within just a few seconds. After that, Stu said that he was off the peg at 60,000. I noted the time and it was about

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MITCHELL 30 seconds after I had steam press pegged that we were down
(CONT'D) around 45,000 to 50,000 on the altimeter. In my opinion, the
steam press pegged somewhere under 80,000 feet, probably
between 70,000 and 80,000. If we had to enter on that and go
by times, I think we might have been in trouble.

SHEPARD How did the time of those compare with the pad time?

MITCHELL I don't know, Al, because I was more interested in watching
steam press. We've been told that's our more accurate check.
If we get the steam press peg at 90,000, that's the thing we
ought to go on. That is what I was doing. It was late
according to all other indications.

SHEPARD Do we have the transcript yet of entry?

MITCHELL I have it right here. We don't have the last part of it. I
started cross checking against the cabin pressure, and sure
enough, my watch was running somewhere between 20 and 30 sec-
onds late from nominal. I started it at steam press peg. I
did not have time to check that. I was using the other check.
We were at 6 pounds of pressure shortly after drogues. It
started moving past 6. I was using cabin press as my cross
check as opposed to time at that point. And the mains did
come out precisely at 10 pounds cabin pressure which would
be right at 10,000 feet.

[REDACTED]

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SHEPARD Okay.

ROOSA The tape insulation on the outside of the command module was tearing off. I could see it.

SHEPARD The Mylar blanket?

ROOSA I had not heard anybody comment on this before. You can see it tearing off and going by the window. The AUTO functions of the drogues and chutes went right by the altimeter. Everything was nominal.

SHEPARD No manual backups were used for any of the auto functions.

ROOSA We were on the chutes and we started going through the checklist. We burned out the fuel and then we purged it. In the CMS, every time you get on the main chutes you set there and the doggone ball rotates around. We commented that we sure wouldn't want to wrap up on the risers like that. When we got on the main chutes, there we were rotating around. We couldn't believe it.

SHEPARD The risers weren't twisting the chutes; they were flying themselves around.

ROOSA Both rings burned out and I hit the purge switch. I saw the red out the window as we purged the rings.

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16.0 LANDING AND RECOVERY

SHEPARD Splashdown was easier than what I had anticipated.

ROOSA I couldn't hear them too well. Seems like there was a lot of talking going on.

SHEPARD There always is that problem as far as comm is concerned. The man in the recovery area is the announcer for everybody, you know.

MITCHELL I might comment that the S-band, right after blackout, was phenomenal through ARIA. That was the first time I'd ever heard of S-band, after the blackout through the ARIA, being any good. From our point of view, it was phenomenal, just as clear as could be.

SHEPARD The fellow who was in a helicopter following us down said, "Okay, stand by for impact on the third mark," and he went MARK, MARK, MARK, and we still hadn't hit. So, he was slightly off.

ROOSA He was off by a 100 feet.

MITCHELL I was standing by to punch in the pyros on his mark. I almost went for them then I realized that we hadn't hit. I counted about 1, 2, 3, and we hit. I went to pyro at that point.

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SHEPARD The impact was very gentle. It didn't seem to be anywhere near what we expected. There was virtually no rotation of the spacecraft. There was a general tipping, perhaps, down toward the feet and back up again. One quick nod and the breakers went in; the mains were released; and there we sat, stable 1. It appeared as though all three chutes released, and that the shroud lines on one of them came down and wrapped around some kind of a fitting up here. That's the reason we still had one chute attached to the top. In any event, it wasn't enough to pull us over into stable 2. We sat there very comfortably, going through the postlanding checklist.

MITCHELL The main bus ties came off at 800 feet.

ROOSA At 800 feet, when you turn off the main bus ties, we still had power on the main busses. And did have after we landed until I got around to pulling the circuit breakers on 275.

MITCHELL I didn't check; I guess it's possible that we could have had a contact failure on the main bus tie switches that kept us hooked up. It certainly was different than in the simulator.

SHEPARD We went over that a couple of times to be sure that we had all the breakers in the right place. As Stu says, in the simulator we powered down the busses, it didn't happen the same way in

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SHEPARD
(CONT'D)

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the spacecraft. There was no over temperature and no high humidity. We went down, opened the vent, and turned it on. Everything was fine. There was nothing flying around in the spacecraft at impact. We were not seasick and had no discomfort. It seemed like they were ready to come in and get us about the same time we were ready to get out. We waited a few minutes before we closed the postlanding vent and waited around a few minutes before we charged the hatch bottle. There wasn't much waiting around. The conversation at that point is good because we have a real good view of what was going on outside. I don't really have any adverse comments at all about that period on the water. Everything seemed to go along just as scheduled.

They were well trained. They had a good spray out there. Those men knew what they were going to do, and they did it, carefully and deliberately. I thought they did an excellent job. We had an opportunity to take a look at the whole TV coverage of it afterwards.

The decontamination swimmer came up and opened the hatch like we'd practiced it. He threw the gear in, and we put it on as we practiced it. It is a little uncomfortable to wear the mask, but at that stage in the game, nobody cares.

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MITCHELL I had one anomaly on the egress that was surprising to me. The CO₂ bottle on my Mae West was loose and the vest would not inflate when I first pulled the handle. With the help of the DECOM swimmer, we troubleshot it, and found the bottle was loose. I tightened it, pulled the lever, and it inflated. The bottle had backed off in the fitting.

SHEPARD After egress to the raft, everything went right on the money and they got us back aboard in record time. It looked like it was just as advertised. It was a clean operation. It always is.

ROOSA The waves must have been less than they were out in the Gulf when we practiced. Getting out of the hatch and into the raft seemed easier than it was in the Gulf.

MITCHELL Eagerness might have had something to do with it. They added the sea anchor to the Billy Pugh nets after we practiced it. That stabilized it quite a bit.

SHEPARD I want to mention that we used the vent procedures for the hatch and the bungee bottle. That enabled the swimmer to get the hatch closed easier. We didn't have any problems with that this time.

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17.0 COMMAND MODULE SYSTEMS OPERATIONS

17.1 GUIDANCE AND NAVIGATION

ROOSA I have nothing to say about the ISS modes. The optics worked fine. One time there was a particle on the telescope just a little beneath the center. It looked like a little piece of material. Later on, it wasn't there. I don't know whether it was frozen condensate or what, but it went away and it never bothered me again. I had no trouble with the optics at any time. All the G&N worked well. The computers worked fine. The only thing I have on the G&N controls and displays was the test switch in the LEB. It wouldn't check all the lights. It would just check the master alarm light. It wouldn't check any of the PGNCs or CMC lights. They worked but that test switch wouldn't check them.

MITCHELL Do you want to mention something on the optical subsystems about the reflected light, the particles, the difficulties seeing stars, even though you mentioned it before?

ROOSA We talked about that. Everyone has commented about it on previous flights. I made a special point of looking, on the way back without the LM, after getting myself dark-adapted to see what I could see through the telescope in

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ROOSA (CONT'D) the way of constellations. We were continually venting and we had a million particles out from us, so the only time I think you could really recognize constellations through the telescope would be in the morning after you've gone all night long without venting.

MITCHELL What about the stray light and the false images that you get on the film? Did you see those? When you're looking at the film and you're photographing the lunar surface in your dim-light photography, there seems to be some false images as a result of refraction in that prism. Did you see that?

ROOSA Did you see some of the film taken through there?

MITCHELL Yes.

ROOSA I haven't seen any film but it sure is there. We commented on that in real time. That must have been the Earth dim light. That's the only dim-light photography we took through the sextant.

MITCHELL It was also evident in your sextant tracking.

ROOSA You have some images in that sextant and we commented on that real time. We had a lot of scattered light and also a false image of the Earth in the sextant.

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MITCHELL It appears to me that the sextant makes a rather poor photographic device.

ROOSA People don't put a lot of stock in that. I didn't realize we had that film back. I'll have to take a look at it. The landmark line of sight has that filter on it. During the P23s, when you look at the Earth's horizon, using the star line of sight you could see the airglow and occasionally we'd get a false image on the sextant. Once you went to attitude and were sighting with the landmark line of sight, that filter really did a tremendous job. It knocked off the airglow and made the Earth's horizon real definite to me. I did notice it cut down a lot on the light transmission, and in many cases it was real dark. Some of the stars that I shot that were out near the Sun had some scattered light. It would tend to wash out that filter and actually made it easier to mark. The double images are no problem running.

SHEPARD I have a comment about the platform. We've looked at a lot of g-sensitive biases and non-g-sensitive biases in simulations and lots of torquing angles that were larger than what we saw during the actual case; but that platform was really right on all the way. We very seldom had a torquing angle

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SHEPARD (CONT'D) that was big as 0.1 degree; usually it was in the hundredths of a degree.

ROOSA You know Y was always the biggest. The X and Z were generally quite a bit lower than Y. If we had any at all, Y was always significantly larger. The G&N was beautiful. I think doing a P51 on the stars would be pretty tough. It would require using the urine bags several hours before the time, but one should be able to do an Earth/Moon or an Earth/Sun and get the area. I don't think there'd be any trouble there. I would have tried a couple of backup modes, backup alinements just tossed in, if we had had the time. I threw those out on entry day because we were stowing the probe and everything and I didn't want to get off the time line.

The CMC SPS TVC was absolutely beautiful and worked as indicated in the simulator without malfunctions. It was solid as a rock with very little transient attitude changes. The steering was solid.

17.2 STABILIZATION AND CONTROL SYSTEM

ROOSA We used the SCS very little — just for attitude hold a few times. I already made my comment about the SCS control at LM undocking. We didn't use the thrust vector control. I

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ROOSA
(CONT'D)

thought our GDC may have been better than what had been reported on past flights. Coming into entry, I ran a 45-minute check and I'd say the GDC drift in that period was on the order of 1 to 1-1/2 degrees or something like that. I thought that the drift was pretty good. We expected a fairly large drift and I guess in reality it wasn't as bad as I anticipated. We kept the GDC alinement up as much as we could trying to have some sort of alinement in case we lost the platform, so we could go back and do a coarse alinement. During a night of PTC, the GDC would get off 15 to 20 degrees. During the day, when we kept tweaking it up, the GDC was beautiful. The EMS was as we had been briefed. It was sort of erratic and jumped around a little bit and we took the DELTA-V_C the people gave us on the pad and loaded it. We reported no bias and that was about all we did, as far as that went. I didn't use it at all on the undocking. I went through the procedures but I thrusted on time and so forth. Anytime we did an RCS burn, like the separation burn or the 0.7-foot midcourse burn, we just took whatever we were showing on the EMS. So we really didn't sweat that much.

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17.3 SERVICE PROPULSION SYSTEM

ROOSA I've already commented on the thrust vector alinement. I thought we got very little transient at any startup. We didn't use any of the DIRECT ON, DIRECT ULLAGE, THRUST ON. We had a 5-psi bias; in other words, with the SPS off, the P_C was indicating a plus 5. During the burns, the P_C itself was a little lower than what I had really expected to see. For example, in the LOI burn in the simulator, with both banks on and after crossover, we'd get up above 105, to 106 or 107. I don't think I ever got to 105 at any time during the mission. It was generally right around 100, not very much over 100. This was of no concern. I just mentioned it because it was a little different from simulations. We've already commented on the PUGS and I want to make sure people go back and get those comments because they weren't as briefed.

SHEPARD Before we leave the SPS, did you want to reiterate on the ball valve, the speed at which the ball valve indicators worked?

MITCHELL The ball valves were moving very slowly and they closed very slowly. They do not work like the CMS.

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ROOSA The THRUST ON light comes on, and then a fraction of a second behind the THRUST ON light, you feel a kick in the pants. It's really a nice feeling. You got down to zero and you see that light, and you're sitting there waiting for it and pow! It comes on and hits you.

17.4 REACTION CONTROL SYSTEM

ROOSA We had no problems with the service module RCS. I think the quads stayed pretty balanced. I thought manual control of the SM RCS was like the simulator, if not better. It was very solid, positive. I've already commented on the CM RCS; we had no troubles. All the quads worked, both rings worked, all the pressures stayed up; I couldn't ask for anything better.

17.5 ELECTRICAL POWER SYSTEM

ROOSA The fuel cells were as advertised. Battery charger went down the line. Whenever the flight plan said to charge, we charged.

MITCHELL I observed that whenever we brought the main bus ties on that, unless the batteries were fully charged up, they were indicating considerably less than the voltage we saw on the simulator. Generally, the batteries were indicating around 31, 32, sometimes 30, and it only took bringing them online for just a few minutes until they were indicating around 27 or 28 on an

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MITCHELL open circuit. So the open-circuit voltage on all the batteries (CONT'D) decreased very rapidly with usage, which was an interesting observation. It didn't upset me particularly, except I hadn't expected it. I expected the open-circuit voltage to stay up around 32 and it didn't.

ROOSA That is a point I'd forgotten, Ed. After my circularization and plane-change burns, I'd go back over and turn the main bus ties off and look at the battery voltage. It was down so far I was amazed at the drop. It called for a battery charge right then.

MITCHELL Well, one reason it becomes important is that in monitoring the bus ties, if you have had the batteries on for a considerable length of time, you don't see any marked change in the battery voltage, when you take the bus ties off. This happened on at least one occasion, and probably more than that.

ROOSA You should look at the current.

MITCHELL Yes. That's a good point. The current monitors are a better indication that the bus ties are on or off, a better indication, than the voltage drop.

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ROOSA Have you got anything to add on the fuel cells, Ed? I think they worked very well.

MITCHELL They worked very well. The only comment I would make is that right before entry, when we took fuel cell 2 off the line, the H₂ and O₂ readouts dropped very slowly to zero whereas in the simulator they zipped to zero. It's just worth it knowing that that's the way it is.

ROOSA I turned the battery charger on and off, and it brought the battery voltage up and the current decreased while it was on. In the dc group, I noticed in our presleep readouts that battery C just stayed right in there. If we'd go back and look, I don't think we'd every see any difference between battery C or the pyro batteries for the entire mission.

MITCHELL If we did, it's probably just parallax in reading it.

ROOSA I think maybe you were reading one at 37.4 and I was reading one at 37.2 or something like that, depending on who read it, but they were right there. We had no problems with the inverters. They were on when we got in and that was the last we played with them.

MITCHELL We didn't mess with them anymore.

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ROOSA On the main bus tie switches, we commented on that one instance at entry. There may be a funny in those.

MITCHELL Yes, just for the record, why don't we get it in here also? When the main bus ties went off before splashdown, it didn't appear that the buses were disconnected or at least the indication in the cockpit was different than in the simulator. And it was surprising to us. We didn't seem to lose main bus power until we pulled the circuit breakers on 275.

ROOSA I don't have any comment on the nonessential bus switch. I played with it a few times during the Hycon troubleshooting. I went from main A to main B and back and forth and I didn't have any problems with it. As far as the platform goes, the G&N power switch was never used. We turned the optics power off each night and I turned it off during the translunar coast when there would be long periods of time when we weren't using the optics on the way out. On the way back, we were using the optics so much that I don't believe it was ever turned off except at night. The cryogenic system went as advertised with the exception of the midcourse, when we got a cryo press light.

MITCHELL Yes.

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ROOSA I guess the theory is stratification in the O₂ tanks.

MITCHELL I might add one more comment about a continual flub on my part. When cycling the H₂ fans, I found the only way I could possibly remember to turn them off was to set the timer. We generally had a checklist book on spring clips up over the switches (which contributed to the problem as well); but for some reason I had a mental block against remembering to turn them off without the timer going.

ROOSA Management of the cryo system was pretty well up to the ground and the flight plan. We did the switching per the flight plan and real-time callouts. I thought the cabin lighting was excellent. We got some Sun shafting in a couple of attitudes, but as far as the darkness operation goes, it was beautiful. We didn't have any trouble at all.

SHEPARD Yes. That's right. Most of the time, we had no problems.

MITCHELL We were always split bus. The only comment we have to make is the one we made earlier that fuel cell 3 was putting out more than the other two, as I guess you'd expect, except the simulator isn't that way. As a result, the gimbal motor transients showed up much more obviously on gimbal motor 2

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MITCHELL than it did on 1. I would suggest as a monitoring technique
(CONT'D) on the gimbal motor using the ammeter, not the fuel cell
flows. There's too much lag.

SHEPARD The comment on split bus probably has to do with maintaining
even modes.

ROOSA Yes, I'm not sure what they're driving at there. We didn't
have any trouble or problems.

MITCHELL We seemed to be running around the 65-, 67-amp current level
almost continuously. And I don't even remember it departing
markedly from that except when we had the gimbal motors on.

17.6 ENVIRONMENTAL CONTROL SYSTEM

ROOSA Other than the comments we've already made on the cabin
pressure, I don't have anything to add here. The flow-rate
test we've already talked about, and I guess we're ready to
talk to the systems people on that. The cabin atmosphere was
fine. On occasion, I was a little chilly, but Al and Ed
weren't, so I guess that was my problem.

MITCHELL You didn't eat enough food, Stu, that's all.

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ROOSA I did mention that I could feel the moisture come up a little bit going through the darkside, but it was certainly no problem.

As far as the water gun went, it was beautiful; I thought the temperature was great. In fact, I was pleasantly surprised. It was nice and cool and the water tasted good. I don't think any of us ever had any problem of the water tasting bad to us or feeling like we were getting too much gas. In fact, whether we used the separator or not, I never really noticed the gas much.

MITCHELL I think if you looked at it carefully, you could see the increase in the gas bubbles without the separator, but we never found it particularly troublesome.

SHEPARD Yes, I think it helps a little bit.

ROOSA Oh, yes. I'm saying it helps, but the way we worked the water and the foot ports, we ended up — We started off putting the separator over on the food preparation panel and trying to use it for hot as well as cold water. We didn't have too much luck with the separator on the hot water. It looked like we built up pressure in the separator and it would always dribble out. We always had a leak in the hot

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(CONT'D)

water faucet anyway. And the separator on there just aggravated the problem. So after a day or 2, we took the separator off and never put it on the hot water again. We left the separator on the water gun and mixed our cold food with our water gun and drank with the water gun. For the hot foods, we just put it right on the tap and used it. It was really troublesome to try to use that separator with the hot water. Even with the separator off the hot water faucet, it still had a bubble everytime you mixed up food; it dribbled a little bit after we were through and ended up with a big ball of water on the end.

MITCHELL We might also comment that we broke the string on the little cap on the hydrogen separator a couple of times and had to repair that. And it invariably was getting in the way when we were flushing out the urine system. It just seemed to find Myrtle and go right on in and wanted to be sucked right down into the systems every time.

ROOSA Yes, and you know that's about a four-handed job to try to hold the cap on Myrtle, Myrtle, and the cap on the separator and squirt the water gun. Just a tab of Velcro on a place where you could stick it on the back of the separator or

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[REDACTED]

ROOSA something like that would be nice, but that little cap on
(CONT'D) there was all over the place all the time.

MITCHELL I think it's probably an appropriate comment for the cap
on Myrtle, too; maybe a tab of Velcro so you can at least
secure the thing while you're using it and flushing it.

ROOSA Are there any other comments on the water system? That's
one system we sure used a lot. We want to make sure we
get all our comments in on that thing.

SHEPARD I don't think we had any real problems other than the ones
we talked about. By a coordinating process, it was not
bothersome the way it was done. So it looks like those
procedures are good.

ROOSA We had no problem with the water-glycol system. Everything
went as advertised. I'd go around about once a day with my
little gray tape and do my screen cleaning and that's about
all we did with the suit circuit system.

SHEPARD Yes, that's got to be a pretty effective system (not only
the return hoses, but also the cabin screen) of clearing
that cabin atmosphere. We were obviously picking up lint
and the system kept the cabin very clean and very few things

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SHEPARD came floating around, except for a little while after Stu
(CONT'D) opened the rock bag right in front of everybody on television.

MITCHELL Yes. I thought maybe we might have gotten some criticism
about that, that we shouldn't have been using the rocks,
but okay.

On the ECS, we knew beforehand we had a bias on the surge
tank, but it didn't give us any trouble. In fact, it was
almost exactly a 50-psi bias; when the cryo DTOs came up,
we were informed about that. I guess the only comment I
would make would be that we should have had that patch in
the CMS a little sooner. Anytime you've got a known bias
on the gages that you use all the time, I think you might
just as well toss it into the CMS. I finally hit Joe
Sundra just a couple of weeks before launch and they got
around to putting that patch in, but we knew we were going
to have that Delta from the time of the altitude chamber
run on. Anything like that that has been bought off and
that is going to be operating in the spacecraft should be
plugged into the CMS, so the crew can get used to looking
at it.

I guess there were a few times we were confused. I was con-
fused in looking at the flight plan. It called for a surge

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MITCHELL tank pressure; and, because almost every other number in the
(CONT'D) flight plan had been corrected to a proper indicated value,
I was confused as to whether the flight plan meant indicated
or true value. In this case, it meant true value and the
number had not been corrected as indicated. Because it was
a 50-pound difference, it was rather significant. This is
what came up on the DTO test.

ROOSA We used the evaporator so little of the time. Did you have
any troubles with that at any time?

MITCHELL No, it came right online when it was supposed to and it was
secured when it was supposed to. It operated as advertised.

ROOSA I think we've commented on the waste management system
pretty thoroughly. We hit Myrtle. I guess we had plenty
of blue bags on board. If you really begin to use many of
them, I don't think you're going to have room in that com-
partment. I don't know how big it is, but it seems like the
last time I tried to get one in there (we had six in there,
I guess), it seemed like we had it pretty well filled up
but that may or may not have been so. We may have been
able to push more down in there.

[REDACTED]

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MITCHELL As a comment, I personally feel in the future that, if there is a choice between the Hycon camera and a better fecal system, we ought to go with the fecal system.

SHEPARD That sure is a messy operation.

MITCHELL Especially when you've been storing it up for about 6 days.

ROOSA The CO₂ absorbers caused no problems. They were all marked and in the right spot. It was a very easy thing as the flight plan would tell you where to do what and we would do it and that was that. I thought there was no hitch in that at all.

SHEPARD That was painless.

17.7 TELECOMMUNICATIONS

ROOSA We've hit everything on telecommunications with the exception of the VERB 64 — as far as the VERB 64 could get the pointing angles. Al, you remember doing that once and it worked out fine. Generally, the ground was always right there with the angles. During the simulations and the flight, I got the idea that the ground prefers their own angles anyway to a VERB 64. I think they're going to be on top of the antenna

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ROOSA and give you all the angles you need. Anybody want to comment
(CONT'D) any further on anything in the communications?

MITCHELL Let me make one little pitch. Maybe it's more in the training area than the communications area, but I still feel, and I guess we all recognize, that handling of the communications system is our weakest point in the simulators. And I would make a strong pitch for the next generations of spacecraft to do more higher fidelity job on communications simulation. I think that, if there was any place I was uncertain about whether I had fouled up or whether it was really the system fouling up, it was in communications; simply because in practicing, you cycled circuit breakers or you threw the switches as per the checklist. However, because you were generally hardlined most of the time anyhow, you didn't get an effect in practice or simulations if you did screw up. So, it never really got home to you — what the effect of making a mistake or having something in a different configuration than you wanted was.

ROOSA For the CMPs coming up next, I really believed the signal strength meter during the simulations and the signal was always there. If I had a good signal strength, I had good comm. In flight, that's not true at all. You can have good

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(CONT'D)

signal strength and not have any comm at all. Now, how that happens I don't know. But there were several cases in which I would have a good signal strength and I would have to go back and break the lock manually, acquire it again, and then I'd have it. I guess in our system debriefing we will hit this a little bit again. I know Ed Fendell touched on this before the flight. I think, as far as future training is concerned, that we should keep in mind that that signal strength really is not an absolute indication that the comm is good.

The only time I used VOX circuitry was during the LM separation and you said you could hear me good.

SHEPARD We didn't use VOX at all.

We just didn't use the portable recorder for anything except entertainment. Had the flight plan not been so full, we might have done some debriefing, but we seemed to be busy all the time doing flight plan items.

ROOSA I know we had plenty of batteries. This was some question about that before the flight. So we really didn't use the tape recorder as much as people had anticipated we would use it. So we had no trouble.

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SHEPARD We did not do any emergency keying.

ROOSA As far as DSE operations were concerned, the ground pretty well handled that. I guess I had to start the recorder a couple of times and I've already talked about the rewind on that one pass.

17.8 MECHANICAL

ROOSA We've already discussed everything under mechanical.

SHEPARD Let me say only one additional thing about the couch struts — about the Y-Y struts being too loose at CDDT. We asked that they be tightened up. There was some question as to whether or not they would be too tight because they were adjusted to the minimum specification clearance. Let me say for the record that we had no problem in locking and unlocking those struts at that clearance value.

ROOSA In fact, you sure didn't want them as loose as they were at CDDT.

SHEPARD I thought they were satisfactory where we had them.

ROOSA During the boost phase, the only time that you got any motion at all was when the couch sort of banged sideways like you were on a railroad train. Everything else was extremely

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ROOSA smooth and it would have been disconcerting to have had all
(CONT'D) the slop that was in there at CDDT.

SHEPARD As far as the strut unlock mechanisms before the landing
were concerned, no problems were experienced. I'm sure
we didn't stroke anything. We didn't hit very hard. Do
you want to say anything additional about the probe?

ROOSA We've covered everything we know about the probe. I don't
think there's anything else we can add to that. We covered
the drogue. If anybody wants to talk any more about the
scratches on the drogue, I'm ready, but I don't think we
need to say anything more here.

SHEPARD We had no problem with hatches.

MITCHELL I guess it's worthy of making a comment on the windows under
this category. Our windows seemed to remain relatively
clean throughout most of the flight. It was noticeable near
the end of the flight that they were crudding up some. From
time to time, we got a little ice on them. But that would
melt off in the Sun. By the last day of the flight, there
were quite a few specks on them so that you really could
notice it. It was cutting your vision a little bit, but I

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[REDACTED]

MITCHELL don't think we were in nearly as poor a shape as has been
(CONT'D) reported on previous flights.

SHEPARD Of course, you're operating pretty close to saturation.
There is some condensation, as Stu has already pointed out,
plus the fact that I think some oil condensed on the windows.
However, I never thought that using first a damp rag
and then a dry cloth would not get the inside of the window
clean enough to photograph through it.

MITCHELL I guess we might caution people about rubbing their noses
against the windows because you will put a smudge on them as
sure as the world, and you'll have to take it off.

[REDACTED]



18.0 LUNAR MODULE SYSTEMS OPERATIONS

SHEPARD I noticed no platform problems at all. I was pleasantly surprised to find that the telescope was easier to use in the real case than it was in the LMS. We've commented about what we think the drift is for the rendezvous radar.

MITCHELL I might remark again, just for emphasis, Al, about problems on the lunar surface. They weren't marked but nevertheless, it is tedious to get those marks on the lunar surface with the AOT. Any shafting light, like off the rendezvous radar, around the back toward the Sun, definitely cuts down on the number of stars you can see. The bright ones are the only ones that are easily picked out.

SHEPARD That's right, particularly at the higher Sun angles like in the alinements close to lift-off when the Sun angles are higher.

MITCHELL I guess that I would make a pitch for all future generation spacecraft to have optic drives rather than fixed optics in which you have to drive the spacecraft around to get star marks. It does take a finite amount of time and fuel to get alinements in the LM.

Rendezvous radar seemed to work great all the way through.

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SHEPARD Outside of the drift we mentioned, the rendezvous radar seemed to work fine as long as the computer was willing to look at it. And the landing radar worked fine. Both rendezvous radar and landing radar passed their test and we got all the numbers if anybody wants them. They're written down. I don't know if there is any need to discuss the LGC anomaly and the abort bit; that's been pretty well discussed.

MITCHELL You want to make any mention of the self-test termination?

SHEPARD Yes, I guess so. The self-test routine in the LGC, which is started after powerup, is entered with the ten code and stopped with the zero code. I thought I'd put both codes in for start and stop. But apparently it did not get the stop code because we were asked to repeat that. When it was repeated, it apparently worked because I haven't heard any more about it. Is that what you're talking about?

MITCHELL I think it's worthy of looking at because it was checked off, and Al and I felt that it had been done. So, whether it actually didn't take that enter or whether we actually forgot it, I don't know at this point. I feel that controls and displays worked just as advertised.

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SHEPARD Such things as cross-pointer operation, tape drives, FDAI operations, and so on are really recognized in the LMS. We didn't run into any surprises at all in that area.

MITCHELL I didn't find the tape meter to be disconcertingly jumpy. In the simulator, I think it has been changed so that it is jumpy, and I think we probably overdid it. I didn't find that tape meter drive disconcerting at all. Did you, Al?

SHEPARD No.

MITCHELL It seemed to be quite smooth and easy to read. We had no trouble with it.

SHEPARD As far as the procedural data is concerned, I guess everybody likes their own checklist, but I think that the way we had it all written out in our checklist enabled us to go through the total flight with a minimum number of miskeys. We didn't have any miskey that I can think of that was at a bad time or screwed up anything too much. So I think, in general, the PGNS was just great, outside of the abort bit.

MITCHELL As far as the AGS is concerned, it functioned absolutely as well as the PGNS. There were no problems. I did notice the larger CAL numbers, and I believe it was in the Y and Z gyros. However, those numbers were known; they were in there;

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(CONT'D)

different people know about them; and they seemed to work quite well. The AGS tracked the PGNS very well both during the descent and the ascent. It takes a lot of practice to do that manual radar updating, but since we're changing the procedure for Apollo 15, maybe they won't run into that. I would suggest, however, as a manual mode that, if you really have to rely on the AGS, you're not going to have the PGNS to help you with that rendezvous radar updating. It takes a lot of practice — many, many hours of practice to do the independent AGS radar updating smoothly, and without making a mistake. In fact, it's the only thing that's going to do it for you. So, I would recommend strongly to follow-on crews that they practice the manual AGS updating with the rendezvous radar in order to not make an error.

SHEPARD I think we were ready for that, although, that's a terrible way to operate it.

MITCHELL It is. We kept AGS independent all the way up through the second midcourse, and it performed admirably and agreed with the PGNS, when given the opportunity to do so. The only inexplicable anomaly we had was the failure right before docking.

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MITCHELL (CONT'D) guess we'll talk more to the systems people about that. I was very pleased with the AGS operation, and it justified every bit of faith we put in it in the past.

SHEPARD We didn't have any opportunity to observe AGS engine commands. As far as the burn programs are concerned, Ed was monitoring AGS as I was monitoring PGNS, and I guess you might want to comment on how you felt they were comparing.

MITCHELL I thought they were comparing within 1 to 1.5 ft/sec DELTA-V or velocity, whichever was being monitored at the time. They were right with PGNS all the way, and so there has never been any hesitation in my mind to shift over to AGS.

SHEPARD We did not notice any control and display problems, other than the one you mentioned with the DEDA base. The outputs to the controls seemed to be fine, for example the AGS ball. All outputs seemed to be good all the way through.

I can't say anything wrong about the propulsion system. The descent or the ascent engines just seemed to be great all the way through. There was no burping or snorting or chugging or anything. We did, on the descent engine, use manual throttle up, and it went very smoothly. The ascent engine, during both burns, was as steady as a rock. The ignitions were crisp.

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(CONT'D)

and the shut-offs were good. There were no problems at all with those engines.

The RCS modes that we used worked fine. The LMS fidelity was good, and I didn't encounter anything during the actual flight that I hadn't already seen in a simulator. We did not use AGS control modes except during the checkout, and they worked just fine then. So, we had no reason to assume that they would not have worked during flight, had we used them. The operation of the translational control system was good. The forces on the handle and the accelerations versus the time of input were just like the simulator showed. We had no problems with either trimming or formation flying.

There were no electrical problems with any of the ACAs or TTCAs. We had no anomalies on the pressurization of the systems. They looked real good all the way through. As we pointed out earlier, outside of the dynamic phases, we operated in pulse almost all the time.

MITCHELL

I don't have much to say about EPS. The battery 5 problem is already well known. It was indicating a few tenths of a volt low with an open circuit. I might comment here, that I was surprised, as in the case of the command module, to find that the open circuit dropped very rapidly from its full-up

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MITCHELL voltage-charged condition with only the removal of a few amps
(CONT'D) or a few watts out of the battery. After we took a few amps out of it, and it open-circuited again, both batteries were approximately 32 volts instead of the 37 that we started with. It wasn't long before we were required to go to high-voltage taps. The low-voltage tap operation was only a few minutes. The dc-monitor switches and gages worked precisely as the simulator showed they would. The ac circuitry worked precisely as expected. We encountered no problem with power transfer between the two vehicles.

SHEPARD It went smoothly.

MITCHELL Very smoothly indeed. I don't know what to say about the abort stage configuration because we actually did all the power transfer before we staged. So, the abort stage really didn't do anything to the power. There are no more comments on the main busses or dead facing. That was all done manually and operated very smoothly.

I'd like to comment a bit on the lighting. There was adequate lighting in the LM, most of the time, without any additional lighting. Of course, only on dark-side passes do we really require lighting. Sometimes you turn a little bit on to light

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MITCHELL a dark corner, but even on the lunar surface we had adequate (CONT'D) lighting in the spacecraft, and I think we used very little lighting.

SHEPARD Yes, we used lighting only during the dark side.

MITCHELL I think Houston asked us about the amount of lighting we were using. If we were really short on power, we could have been much more conscientious about turning our lights off when we weren't using them, to save a few amp/hours.

SHEPARD Some lighting is required in the interior of the LM during the surface stay because you're almost directly down-Sun, and there's not much reflected light coming in. For such things as the timers, the rheostats had to be turned up a little to see them, but generally speaking, the lighting was good.

MITCHELL I think we can add the comments that, just for general work in the cockpit, there's adequate reflected light, but if you want to look at something particular on a panel somewhere, you probably need to turn the light up.

SHEPARD We apparently had no problems in the main oxygen supply system of the cabin except for the one preflight problem, which everybody knew about, and that was the bias and the transducer for

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SHEPARD (CONT'D) the number 1 ascent O₂ tank. I felt it might be a problem on the ground and we'd have to worry about monitoring it. However, the one monitoring technique we had through the PLSS-recharge line-pressure transducer, had to be used only once, and that was as clean as could be. So, we didn't have to fret with that bias at all.

MITCHELL And the cabin was tight so that, even during the entire rendezvous, it stayed at the bottom of the green band. So, we didn't lose any oxygen in depressing the cabin.

SHEPARD The LCG cooling was more than adequate. I didn't use it all on my side.

MITCHELL I turned it up occasionally to get a shot of cooling and then immediately turned it back down, because it does chill you if you leave it much above the minimum setting.

SHEPARD We had no water problems. We used the water gun and drank freely from it. It didn't leak and it worked fine. And of course, we used it during the recharge process on the EMUs. We'll probably get into that later on, but it worked as advertised.

MITCHELL Let me make a pitch in here, while we're talking about the ECS. Trying to rendezvous with helmets on is a bloody nuisance.

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MITCHELL (CONT'D) Grumman has always been very upset about the idea of flying in the LM without a full suit integrity, and it appears to me, that if we're willing to sit on the lunar surface without our helmets and gloves on, we ought to be able to take them off after we are in orbit.

SLAYTON It is pilot option as far as we are concerned.

MITCHELL Grumman doesn't like it at all. They always fuss about it.

SHEPARD When you try to follow the checklist religiously for days, you get a little nervous doing something the checklist doesn't specifically tell you to do.

MITCHELL Yes. And if you're going to take your helmets off, you ought to go to the CABIN position of the oxygen regulators and the REPRESS position on valve. But just as sure as you do that, the ground is going to holler at you when you come around the corner AOS. So, we elected not to change those valves, and I think we ought to make it loud and clear and get the system to agree that that's an acceptable thing to do.

The suit circuit is the only thing we haven't discussed. It performed as advertised.

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MITCHELL I guess we have criticized the S-band steerable antenna enough
(CONT'D) during the other parts of the debriefing that there's nothing more to be said here. It was erratic in operation. At some times, it worked admirably; at other times, it gave us fits.

SHEPARD We talked previously about our VHF problems. The EVA antenna went up and came down like it was supposed to, so it operated well mechanically. We had no electronics problems with it. The audio centers worked fine, and there were no problems with the recorders.

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19.0 FLIGHT DATA FILE

19.1 CSM

SHEPARD I didn't see anything bad about these things since we helped author most of them.

ROOSA I think Chuck Stough and his associates did a great job. I think they were more than eager to work with us in anything that we had. I started working with Chuck real early on the flight plan and the Solo Book. They were more than eager to try to make it the way we wanted it. I think the system worked real well because back when we said we would go with one flight plan in January and a different one in March, everybody held the line and there were few changes. I think the system reacted to that exceptionally well. Probably that cryo DTO was about the only thing that came in after that time frame, so the system is to be congratulated on that one.

MITCHELL The only thing that I might add here, Stu, is in reiteration of the idea that we would perhaps need to change the format for the entry of the update format.

ROOSA The next crew should take a look at the data they are getting on the entry checklist to see if they want to change that and everything else I read down here: the checklist, the cue

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cards. We've already commented on how we need to break out all those P23s and add a couple of pages in the Solo Book. I thought my Solo Book was very good.

MITCHELL

In all fairness, we'd have to say that we didn't really exercise anything but the nominal parts of the flight data file. So, everything else is untried. The Systems Data, the Malfunction Procedures — none of those were even opened.

ROOSA

I have to make just a couple of comments on the lunar graphics. Before flight, we had a lot of discussion comparing the shaded relief orbit map with the photomosaic map. Actually, I think the shaded relief map doesn't really give you what you want, but it is perfectly adequate. I was not sure the shaded relief map was good in telling me what I wanted to know in orbit. By the time I got to orbit, I knew the groundtracks so well that I really didn't need that map. If you really need a map to get you around the orbit, the shaded relief map is not very good. About the only time that I can remember looking for something specific on that shaded relief map was Lansberg B. I had already looked at it on another photomosaic. All the targets you're specifically interested in — your landmarks, your zero-phase targets, this sort of thing — you have a photomosaic. I guess you carry the orbital chart

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ROOSA
(CONT'D)

just to keep you in the general area and identify the large features, and it's adequate for that. But, you get no good identification from the shaded relief map. The rest of the graphics — the lunar graphics book itself, I thought, was very good. The photos of the landmarks are so good you can just take them and run them even if you have never seen them before. I didn't even use the contingency map. Ed looked at it and decided it was pretty worthless. That map by its nature has to be that way because it's got to cover such a large area.

MITCHELL The shaded relief map, too.

ROOSA Yes.

19.2 LM

SHEPARD Well, as far as the LM is concerned, I'd like to echo Stu's comment. I thought the preflight support here in Houston and at the Cape was excellent. The system was very responsive. I felt we were in great shape on all the items we used. Again, as in the command module, we didn't use any of the contingency items, but we had used them in preflight simulations and felt our total data file was in good shape in all respects.

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MITCHELL You can arrange these items and package them almost to crew preference, I guess. Everyone has his own feelings about how the different books should be packaged. They worked fine for us and I was very satisfied with the way we had them packaged. I have a couple of comments on the LM Orbital Monitor Chart. Preflight, I didn't really see the need for an Orbital Monitor Chart that covered the entire Moon. Thus, I didn't make any effort to change the one we had. It turns out I would have liked to have had it because on a couple of the back-side passes, there wasn't much time to move around, and there was no chart that covered that area. Our chart only started a short distance before the landing and I really didn't know where we were except in very general terms.

SHEPARD I wouldn't make a recommendation to change that though. I would think that the chances of using that on the back side were so slight. Assuming everything was going fine, you ordinarily wouldn't have time to look around.

MITCHELL Well, all you have to do is just add a couple of leaves to it. The information is already there. They just happened to cut our chart off so that it was thinner, that's all. You can get along without that. I would suggest including the Ascent Monitor Chart. We didn't have to use it, and I

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always looked at it critically during the last few days before launch when we were flying manual ascents. I don't think that our Ascent Monitor Charts are adequate for either pilot manually to fly an ascent and control the azimuth as you go into orbit. We need to look at that again. Specific comments are that you need very precise navigation immediately after lift-off, and we didn't have a track plotted on anything. I think the orbit started properly. Then, on the large-scale maps, the detail is not there to help you plot it. Especially in the Fra Mauro area where, as soon as we left the landing site, there was bare nothingness. So, I suggest the following crews look at that Ascent Monitor Chart and see if they can get something suitable for their particular landing site and their needs for a manual, direct ascent. Everything else was in excellent shape.

ROOSA

The 650,000 map that I had, I didn't even use. It was on board because I guess it had been on board. I never looked at it. All the maps in the Solo Book are sort of an individual thing. Everybody makes up his own mind on that. The simulated obliques that we made up — I don't know how much it costs to make those obliques — I really found those of marginal use, also. So, if we're looking for ways to cut down on cost, I would take a look at the obliques. I just didn't find those too useful, particularly on the zero-phase section.

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MITCHELL Now one simulated oblique on a low-altitude landmark, if it's easy to obtain, might help you out a little bit.

I think preflight everyone was instilled with a fear we wouldn't recognize where we were around the Moon. By and large, after a couple of passes around with one map, those craters stand out more. Whether you know them at all or not you can spot them right away.

ROOSA Yes, the orbital work was so much easier than I expected. Looking back at the preflight worry over the maps, I think perhaps it wasn't worth it.

MITCHELL Maybe all that work is what made that possible, Stu?

ROOSA Yes.

19.3 CHARTS AND MAPS

ROOSA On map updates, the first day in lunar orbit, I was copying the 180-degree crossing time and I never used it once. Finally, I told them to stop for the second day's operation. It's just that much more data the CAP COMM has to read up and you have to copy. Your maps are set up for time after the 180th meridian. As soon as you come out in the light at the terminator, you look out the window, see a crater, and

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know where you are. And from then on, you can go on that. So, I did not use the 180-degree time on a single occasion. If I were going to rewrite my Solo Book today, I wouldn't even have a map update in it.

MITCHELL

Again, I think that was because you were so familiar with those maps.

ROOSA

Any CMP's going to be as proficient when he gets there. Again, I think those are such personal things, they're probably not worth recommending.

MITCHELL

I have one more comment that we made previously, but needs to be included in this section. The EVA-preparation and post-EVA cards. We need to find a different way to tether them to the main panel, when we're accomplishing EVA preparation.

SHEPARD

Our EVA traverse maps were satisfactory. I would make no other additional comment, although I think the scale map should be used in geology field trips before you actually get to the lunar surface. We did that on our last two or three trips. The last two geology field trips were in areas previously unfamiliar to us. We used that scale and I think that helped.

MITCHELL

Very definitely.

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19.4 GENERAL FLIGHT PLANNING (FDF)

SHEPARD That's the kind of information that will vary from crew to crew because there will be some changes necessary as a result of changes in mission objectives, or DTOs or updates to programs. These things are going to be going on all the time and each crew tries to make as few changes as they can. However, personal preferences are always going to get through.

ROOSA I think the Solo Book has to be a personal thing. I don't think you can take one Solo Book and say that, because it's good on this flight, it should be good on the next flight. I think it's made up only for the individual and should be shaped the way he wants it. I think this system is well geared for that.

MITCHELL Especially because the book is a cue to your memory. The cues for one crewman may not cue the next CMP too well.

ROOSA Yes, that's right. In parts of my Solo Book, I wanted every step listed. I didn't want to trust anything to memory and perhaps the next guy thinks he has a fabulous memory and maybe he doesn't want as many cues.

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19.5 PREFLIGHT SUPPORT

SHEPARD As far as I'm concerned, the system is in excellent shape and I can't think of any derogatory or negative comments about the preflight support that we had at all.

MITCHELL The changes that did come through, came through in exceptionally smooth fashion. The system at the Cape worked well. The communications linked back here by telephone were kept to a minimum. Whenever changes did come through, the book managers always gave us a call and the Cape coordinated with us before they pushed it on through. In my opinion, the system worked admirably.

ROOSA This is a small thing, but I know it came up a couple of times. They always ensured that one copy of the changes to the checklist and flight data file, as they went in, got to me if it concerned the CSM or the Solo Book. This worked well. I used to take those and read them in the evening, and I was never sure what items got to Ron, or whether or not he wanted that whole stack. I think that the backup crew should get those same changes. It may have been that I was supposed to read them and pass them on to him, but it seemed as if we always had a little conflict there. I'd be aware of changes that Ron was not. It's just a matter of making another copy

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and putting them on his desk, too. There were several changes that resulted from meetings that I was aware of and Ron wasn't. Ron and I talked a lot and we worked together closely. But it's just a matter of two crews on two different schedules.

MITCHELL

Yes I felt that, by and large, when those change copies came through, I'd already know about them by telephone, probably before they came through. I was never sure whether I'd mentioned them to Joe or whether he'd gotten a copy of them. It took a great deal of effort to coordinate with him.

ROOSA

I think it would be a good change. I really think our backup crew was tied in closer than some of the other ones and Ron did a great job in trying to stay up; however, in this one area, we sort of dropped him out.

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20.0 FLIGHT EQUIPMENT

CSM

ROOSA We had no trouble with any clock except maybe a wristwatch. Our mission timers were beautiful. The event timers and controls caused no problems. The crew compartment configuration goes back to my hero, Ray Dell'Osso. He was there. Everything was properly configured and I was thoroughly briefed. I had worked in the mockup and it was great. I never used a mirror.

MITCHELL I think that my Omega might have gotten some dirt or something in it because it would not run when it wound down very much. I had to keep it wound up at all times, and so I was winding it three or four times a day. It stopped on one occasion when I don't think it should have.

ROOSA It was a pleasant surprise to us that the pockets in our coveralls had zippers on them. Our training coveralls had flaps on them, and everybody we talked to had talked about the flaps. But, when we took our coveralls out of the PGA bag, there were zippers on the pockets. I don't think we could have kept things in our pockets without the zippers, so that was a very pleasant surprise. I guess the other thing related to the IV clothing would be that one dosimeter that crunched out, and we commented

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(CONT'D)

on that. The other dosimeters were carried in the pockets. They didn't get out, and we could drag them out each morning and read them. My PGA worked fine. We've already talked about couches. I did not take down the center couch before the rendezvous so I did not do any dismantling of the couches at all. We had no trouble with the restraints. They were out of the way. I kind of expected them to be floating around in the way a little more than they were, but I didn't have any problems at all. We actually used the inflight tool set when we took the probe apart, and Al took tool R with him to the LM.

SHEPARD I brought it back.

ROOSA That's right. I don't know what they mean by data collection here.

SHEPARD I don't either.

ROOSA I think we've commented on the thermal control. We had no major condensation problems.

Well, we've talked about the Hycon. I also mentioned that the 70-mm PCM cable was not long enough to reach the center hatch bracket. I also commented on the intervalometer, that we'd get a double firing every now and then. I sure wish we had a

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ROOSA (CONT'D) variable intervalometer. The other camera equipment worked fine. We had no cameras jam, no magazines jam in the command module at all, and I can't think of anything else to add on the camera equipment.

LM

SHEPARD As far as crew compartment configuration is concerned, my only comment is that it's just tight. There just really isn't any extra space around there on that thing, and I felt that the preflight training we had done on the mockup down at the Cape was invaluable in that respect and in the pre-EVA and post-EVA planning. It helped us immeasurably in that area and I think that any crew that's going to have to operate inside that compartment will have to do the same thing.

MITCHELL Yes, if you don't practice it, it's just going to be complete chaos.

SHEPARD If everything doesn't go in its place the way it's supposed to and the way it's been worked out, it just gets all jumbled around.

MITCHELL There was not enough stowage area for filled urine bags, and maybe we can take a look at that.

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SHEPARD We've already talked about that. The restraint system worked as advertised.

MITCHELL I feel that the pull on that restraint system is still a little bit strong, but it doesn't slow you down particularly.

SHEPARD The tools we used were the special tools we took with us for dismantling the vehicle. No LM tools were used because we didn't have any occasion to use them. Do we comment about EVA cameras here?

MITCHELL Let me talk about the flight camera first. The mounting for the 16-mm camera on the crash bar worked very well. It's a very hard thing to do in one g, because the camera won't stay on that bar. However, in one-sixth g, with a little bit of tape around the crash bar to give added friction on the utility bracket, the camera holds on there very well, is steady, and takes good pictures. That's a good way to do it. It's no great trick to slip the camera from one bracket to the other. That particular kluge worked very nicely.

SHEPARD I don't know why, but, during the flight, I had a problem with the tightening screw on the handle of the Hasselblad I used. I had never had a problem with that before in any of the training cameras that we have used. For some reason, I couldn't

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SHEPARD (CONT'D) seem to get that thing tight enough to keep it from loosening up. I don't know what the problem was exactly. The handle never did come off, but it was always flopping around and I had to keep tightening it up all the time to keep the thing operable.

MITCHELL I guess to summarize, on the LM equipment, you can't argue with the successful way that the guys had it stowed for us and the way we operated with it.

SHEPARD Yes, I think that our camera problems were certainly superficial.

MITCHELL In this section, I'd like to reiterate the problem we had with keeping the ISA in the PLSS stowage area. It wouldn't stay in that particular location at all.

[REDACTED]

[REDACTED]

[REDACTED]

21.0 EMU SYSTEMS

SHEPARD Why don't I just go through the discussion of my EMU systems and you can go through yours, and you can go through yours, Stu. The biomed sensor problems have already been mentioned. LCG operated satisfactorily. I found that I had to cut the strap that held those hoses where they manifolded together; they come up under the vertical riser on the underwear. I cut them loose to make a good fold to prevent bunching underneath the suit. Once that little retention strap was cut, everything worked fine. I had no problems with the helmet and no problems with the LEVA. I had no problems with my gloves; my skinned knuckles are finally healed. We discussed the bent hose in the UCTA. I used the EMU maintenance kit only as we had described before, to clean the seals one time between EVAs. It wasn't a problem. The drink bag worked fine, and antifog worked fine. I had no problems with the PLSS other than the strap problems which we discussed before. Cooling was good. Comm was good. No problems with connectors, no problems with controls. RCU preflight adjustment problem was discussed, no other problems. The OPS worked fine, no leaks. We did not use the BSLSS.

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MITCHELL No problems with the biomed sensors. They've already been documented. I might add, in addition to that, that the sensors caused me no problem until after the EVA. They started itching and irritating a little bit at that point. It wasn't where I couldn't live with it but it was uncomfortable. I did have a few skin eruptions under the sensors postflight.

SHEPARD And he still has those.

MITCHELL The LCG worked properly. And the helmet and LEVA operations were all right, except it certainly is easy to scratch up the helmet and the LEVA. The scratches cause shafting light or diffused light problems and that obstructs your vision. All I can say is that you have to be darn careful with them when you're using them. Just the slightest touch can cause a scratch. My glove problem has been documented already. Let's see, my UCTA worked fine. I always used it with trepidation, but nevertheless it didn't fail. We will skip EMU maintenance, because Al described it. I thought I exhausted my drink bag on the first EVA. I was very surprised at how quickly it seemed to empty. Sure enough, I had not emptied it, because when I went to bed that night, with the 7-degree right wing down, it drained around my neck. So, there had to be some residual water in it. I think what probably happened was I sucked the bag up

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MITCHELL
(CONT'D)

against the inlet to the hose and just cut off the flow. It was very welcome on the second EVA and I did drain it on that one. I might remark that the antifog we had on the flight seemed to be much fresher than the antifog we used in training. It didn't smell as much like a barn, which was a pleasant relief. I have some comments on the PLSS PGA operations. The OPS brings to mind all the push-to-dot fasteners on them. I know that my fingers got completely worn out before the lunar surface operations were over. Not only with the OPS push-to-dot, but with all the rest of them. In the training operations, we used those things enough that they came off fairly easily. But on new equipment and new hardware, those things are so stiff and there are so many of them it really gets to your fingers; you're sore before the operation is over. And I mean really sore. So sore you can hardly touch them at times. The only thing I can suggest is maybe it wouldn't hurt for the troops that are PIAing and looking over that equipment to cycle them a few more times and maybe loosen them up just a tad.

SHEPARD All right, to wrap up the comments as far as the EMUs are concerned, I guess we probably put more time in our suits than previous crews have. I felt that it was all worth it. I never at any time felt unfamiliar, ill at ease, or had any

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(CONT'D)

concern about the operation of the total package. I think the time we spent in the suits before the flight in preflight training was well worth it. We got our money's worth in those training suits.

MITCHELL

The only way to get where you can ignore the discomfort and the difficulty in operating the suit is just go and do it until you can ignore the problems with it.

SHEPARD

Okay, Stu; do you have anything?

ROOSA

Gee, my suit fit so well and getting in and out of the suit went so smooth, I guess my only comment would be to echo the rash on the biomed sensors. I don't know if that's a problem that can be overcome or not. Mine started approximately 2 days out. I started getting a rash and itching on my chest and it stayed with me the rest of the time. I still have a rash now. It was no big deal. It's just something that itches a little bit. I don't know if there's any solution for it, but if you wear a sensor for 9 days, you know you're bound to get a little irritation. That's my only comment on the thing. And other than that, all the suited operations that I did went extremely well. I think all of the times when I got in and out of the suit by myself during the training was well worthwhile. I think that was really good, because then it just makes it so easy in flight.

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22.0 VISUAL SIGHTINGS

SHEPARD During countdown, we saw a few clouds out the window; that's about all we saw.

ROOSA We saw no rain. I don't see anything about this that we have to talk about.

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23.0 PREMISSION PLANNING

MISSION PLAN

SHEPARD I think anything we say about how our mission plan was developed would not necessarily apply to the development of anybody else's mission plans. Spacecraft changes, procedure changes — these are rather unique to the missions themselves.

MISSION RULES AND TECHNIQUES

MITCHELL I would make one comment on mission rules. I think we made a concerted effort with our flight directors long in advance of the mission to review those rules, which we considered either not applicable or holdovers from previous missions, and had ultraconservatism in them. We discussed, in great length, those mission rules which looked like they might be subject to change in real time and tried to make them realistic. I think each mission ought to do that — to review the ancient rules that have been held over and get them resolved preflight. I don't believe at all in having mission rules and, at the same time, saying, "Okay, we'll probably not abide by that in real time." I think mission rules ought to be mission rules and you know that you're going to abide by them if the occasion arises. And I think we did a good job of reviewing them with that in mind.

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SHEPARD Well, I think that certainly the data priority group and Phil Shaffer did a hell of a good job. I think that certainly his coordination book was a good one. It seems that when you give him an item to coordinate, he seems to have the right avenues of coordination, because he shakes everybody out of the trees and there doesn't seem to be anybody he misses. So it seems to work pretty well, as far as those kinds of changes are concerned. And we worked well with him; I think he and his group are good people to work with.

ROOSA You know, on the same subject as this, we're talking about there though, mission rules that are written with the idea of, well we'll change that if it really happens, and I think a good example of that happened on launch. Your biomed, you know, there's a mission rule that says it's mandatory to have a biomed on you, which they waived. Well, I think it's a bad mission rule to start with — this thing that you're going to hold up a launch because you're not getting biomed on a crewmember. There are mission rules like that that I think should not be in there.

SHEPARD Well, the whole mission rules volume is so voluminous that at least I didn't look at all of those. I looked at the summary of them, you know, and tried to work on what we

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SHEPARD thought those ought to be and to hell with the rest of the
(CONT'D) big thick book. I'm sure a lot of others are archaic.

MITCHELL Well, that's what prompted my comments here. There are so
darn many that you just don't ever review all of them on
each mission. It's a continuous process.

ROOSA You get down to the nitty gritty, but now like anything up to
launch; you know, you really don't have time to even worry
about those. That's probably where that one was hidden in
there.

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24.0 MISSION CONTROL

SHEPARD Well, let me start out with a general comment that I thought that Mission Control was excellent. The overall work that we did with the control teams prior to the flight in the mission simulations, I think, brought out lots of problems, that is, semantics, and these had all been solved, by the time the flight lifted off. Again, one of my favorite subjects is that I feel, the fact that we had astronauts involved as communicators on all these shifts, helps to smooth out the semantics problems. And shifting into the first item, GO/NO GO's, I felt that those were good. I never felt that I was waiting on the edge of my chair for a GO or NO-GO from Mission Control. At any time, they're always prompt and certainly on time. Updates, I think we've talked about the areas where we thought the updates were superfluous.

ROOSA I don't have anything else to add to that.

SHEPARD The consumables updates were fine. We charted most of those as far as the command module is concerned. Everything was so nominal in those areas that really the consumables charts didn't become a factor.

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MITCHELL As long as we had as much reserve and as much margin as we did in all systems, there was never a concern in your mind when you were close to the line or not.

ROOSA We started off low on the RCS fuel. We made that up at the first opportunity.

SHEPARD As far as real-time changes are concerned, we discussed most of those in detail already, but, I would like to reiterate that the real-time changes, as far as the LM PDI sequence to touchdown is concerned, I thought was really handled remarkably. From our point of view, it couldn't have been better.

MITCHELL I think we had sufficient rapport, understanding, and agreement with the flight controllers that we saw a minimum of procedural changes during the flight, only those dictated by contingency. I was real pleased to see that, because it hasn't always been that way. We've done a lot of procedural changes in real time in the past. I had hoped that we could avoid it on this flight, and I was very gratified to see that we did avoid it.

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25.0 TRAINING

CMS

ROOSA I think we have already commented (or have we?) on the stowage of the CMS. It turned out to be excellent. We ended up the last part of the training with things stowed extremely well. The fidelity of the CMS, I thought, was absolutely super. No question on the availability; it was there. The visual systems: I have talked with John Mitchell on this and also Riley. If we are spending any money for those films in the optics, we should discontinue it. It is my understanding that it is just as easy to leave the visual system alone as it is to take it out. In fact, it might even be cheaper. But the films for the landmark tracking are never calibrated with your orbit, it seems. So, they really don't do you that much good. You don't need them. If it is costing us a penny, we ought to think seriously about doing away with them. Films out of any other window but the optics are really a waste of time. Just prior to the flight, I did take a look at some of the lunar horizons out some of the windows. I don't think they are trying to keep those systems up well either. I think if it is any money savings at all, they should take them out of all the windows.

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ROOSA
(CONT'D)

As far as the star ball goes, that's in good shape. In fact, the star ball through the telescope gives you too much light transmission. There is not much to say about CMS software. I don't think there are any major differences between the CMS and the CMC. I guess in some cases the actual CM computer has the tendency to round off a little more than it does in the CMS, but this is such a minor thing that it is hardly worth noting. I would say, overall, the training in the CMS was excellent. I certainly got plenty of time. I think Roger Burke on CMS-1 is the only one in the system who is really on top of the G&N as far as the training goes. He is aggressive, he is extremely smart, and he pursued the subject. Whenever I had a lot of any detailed G&N questions, I would always be calling back to Roger on the telephone. He really is the giant among the training people, as far as I'm concerned, as to knowledge of the G&N.

LMS

SHEPARD

We will go ahead with the LMS comments. I thought that the LMS was excellent, also. We put a lot of time in it. It was very much — could be the single most important training device of the whole spectrum. We didn't really use the LMS for crew station stowage since we had a mockup at the Cape

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for that purpose. So, we didn't really use the LMS for stowage, and that situation should continue as long as you maintain that mockup for that purpose. It is a lot easier to go into the mockup and bang around with suits on, pressurized, and with lightweight PLSSs than it is in the LMS.

As to LMS fidelity, I didn't notice any difference in any of the flight parameters. In the LMS, obviously, you can use all the contingency modes. Of the contingency modes which we did use, I was not surprised by any inequalities or infidelity of the instrument presentations, decals, or anything. I thought the LMS fidelity was extremely good.

We had no problems with LMS availability once we got to the Cape. There were some times in Houston, early in training, when we had to cancel a couple of times because of switchover of tapes or something which held us up. But, certainly simulator availability at the Cape was never a problem.

I will leave the L&A out for comment later. The starball was good. For the manual ascents we specifically had, the horizon had to be picked up and calibrated ahead of time. It was not automatically in for the condition that we used through the overhead window; but you knew ahead of time you were going to run one so they could get it all calibrated and the manual

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ascents could be done. The AOT in the LM doesn't have any blind spots in it like it does in the LMS. The software in the LMS was very close to the flight ropes. In general, I thought it was very good.

MITCHELL

I would like to add that I think the follow-on crews ought to take advantage of the ability to shift the visual system to the right window and to use it there quite a bit. We didn't do this until near the end of training, and I found it quite valuable. I would recommend we do some practice of the manual lift-off with the visual display in the right window. I don't think the display we have down there is quite adequate for it. I am not sure that it requires a high-fidelity tape or high-fidelity film to do it, because what you are really practicing is a tracking pass. If we can put a film in that right-hand window that the LMP can practice tracking on, it doesn't really matter whether it is high-fidelity lunar landscape or not. You can always find this landmark chart, provided you get a good ascent marker chart. The LMS was an exceptionally good training device, and I have no complaints about it.

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CMS/LMS INTEGRATED SIMULATION

SHEPARD As for integrating between the CMS and the LMS, I had no way of knowing whether our problems of integration were any more or any less than the previous crews. We did have a few times when we took the simulation unintegrated because we couldn't get it going because of buffer problems and on-line computer problems. But, somehow we seemed to get it done. I suppose that the procedure is so complex that there is bound to be some start-up problem when you try to run two of them together. I didn't feel we were suffering from lack of integrated simulations. I think that's about right.

MITCHELL I think they are very valuable training at a certain point in time. Once you reach that point, it is very important to do quite a bit of it, because you have all your time lines and your checklists fully coordinated between two vehicles. Even now, the semantics problem exists of having to communicate between vehicles.

ROOSA That is another advantage of the short rendezvous. You can get in a bunch more in one session — two, maybe three rendezvous in a day, which is pretty good.

SHEPARD So, from a real-time standpoint, this has been a valuable tool so the two can talk to each other.

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NETWORK SIMULATIONS

SHEPARD We had — what? — 1 or 2 days more than we have had previously?

WARD Five more.

SHEPARD These are always valuable. It is up to each crew to weigh whether or not they need simulated network simulations more than anything else at that late point in the training. We chose to do every one that was scheduled. We even did the optional one. I feel that every one that we did was certainly advantageous to us, because you're not always talking in the same terms as the FOD people. You get to the simulated network simulations, and you work directly with them on a realistic basis. You really get a feel for how it's going to be during the flight.

MITCHELL I don't know how the simulations people did it. It was a very fine job of getting through them and, at the same time, realistic on their simulations. They gave us a good workout; yet, at the same time, did not go overboard in nit-picking little things that really don't amount to anything. They gave us good hard-core failures to play with and train on. We were very impressed with that.

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ROOSA I would like to make a comment on the simulated network simulations. I made this comment after we were well into the simulations, and I think it got fed back to the simulations people about comm malfunctions. I think they have a reluctance to put in comm malfunctions during simulated network simulations because they are afraid they may blow the simulation. Personally, I would like to see more comm malfunctions in the simulated network simulations. There is no way to simulate communications until you are tied in with Houston. That is not the time to be reluctant about putting in comm malfunctions because it is the only place in the system that you can get it. If you put in some comm malfunctions, and you blow a PDI simulation or rendezvous simulation, then at least everybody has learned a lot about comm out of it. You can pick up that simulation later. They really ought to bore in on the comm problems on those simulations.

MITCHELL I agree with that comment.

DCPS

SHEPARD DCPS is a good training device. I would not have wanted any less training than we had on the DCPS. There is no other place that I know of where you get the latest dope on launch. I think Mike Wash has done a continually fine job in that

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SHEPARD
(CONT'D)

area. He is up to speed on all information coming out of Huntsville on crew procedures. He was always a willing instructor and, I think, one who conveys the subject very well to his students. I can't really say enough for his capability.

ROOSA

It is the one source in the system that you can always go to and get the latest straight answer on the DCPS. He is really good.

LMPS

SHEPARD

I didn't use the LMPS very much. I didn't use it at all. We used it for a couple of practice rendezvous.

MITCHELL

I used it very early in the training cycle. My opinion on the LMPS is that it is good for running G&N systems for people who have not been through a training cycle before or who do not have access to the LMS. But once you have access to an LMS, it is not really worth your time to work with the LMPS.

CMPS

ROOSA

I recorded a good bit of time in the CMPS during the earlier part of the training cycle. I think it is a valuable tool even late in the training cycle, not so much for the machinery

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ROOSA
(CONT'D)

of the CMPS but for the people whom you have assembled. You have a group of people there, who up until quite late in our training cycle, were boresighted only on rendezvous. I think they have now switched to entry simulations, also. You have this group who do nothing but boresight in on the rendezvous phase. You can get some real good instruction out of them even though the machine you are sitting in certainly hasn't the fidelity of the CMS. I got a lot of good instruction on rendezvous out of the CMPS. I thought it was very worthwhile.

CENTRIFUGE

SHEPARD

Centrifuge is the next item. We have a lot of experience now on acceleration in the transverse position. I am not sure that the centrifuge is as worthwhile now as it used to be. I think perhaps a refresher ride for everybody every so often is worth while. It is kind of like going to the altitude chamber. You have to do it once a year, maybe just as a refresher training item. Perhaps the CMP may want to assure himself that he can fly the vehicle under those acceleration loads one time more as a confidence builder.

ROOSA

I am not sure that the centrifuge is available to us. If the centrifuge were available, I think it would be extremely valuable for the CMP just to fly it — fly EMS entries on it.

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ROOSA
(CONT'D)

The CMP, faced with the EMS entry, will feel a lot better about it if he performed quite a few of those on the centrifuge. I don't think you need to get used to, or try to get accustomed to the g aspect, but I think it is the idea of integrating the control task of the EMS type entry with the g load.

SHEPARD

Well, I think all the other guys who are faced with the probability of working the hand controls are going to feel like they should have tried it on the centrifuge.

ROOSA

The other guy (CDR) is just going to have to do it if we are ever faced with a manual entry. I think that doggone centrifuge would be valuable time then.

TDS

SHEPARD

I worked on that and thought it was valuable for me. I never had to dock in that mode but always felt that if the occasion ever arose I was adequately prepared to do it.

ROOSA

I used it in the command module mode several times until they tore it down. The initial dockings were just like the TDS; you just drive into the drogue and stop. It just felt like the same way.

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ROOSA
(CONT'D)

I don't think you need it. We don't have it now, but I don't think you need it at all.

SHEPARD

I think that the fidelity of the visuals now, both in the LMS and the CMS, is adequate for this task.

NR EVALUATOR AND GAC FMES

ROOSA

The docking training you get in the CMS is more than adequate. I used the North American Evaluator about 2 years ago now — anyway, quite early in the training cycle — and it was all right because there wasn't anything else available. I never did fly the actual hardware evaluator.

MITCHELL

I used the FMES early in the game. With the fidelity of the LMS at this point in time, I don't think it is a necessary training device. If any questions arise that cannot be adequately answered on the LMS, we can always pose the question back to Grumman and let them work it out. In looking at the fidelity of the systems, it is not necessary as a training device anymore.

SHEPARD

When the availability of the LMS wasn't good, it was used as a backup. But, I wouldn't suggest its use any more.

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EGRESS TRAINING

SHEPARD That is something everybody ought to go through once. Once is enough.

MITCHELL I think we are overdoing egress training at the Cape. When we went through egress training for the chamber and egress training for the PAD, in my recollection, we went through the darn thing three times, didn't we?

ROOSA Well, that was just because of the slipping in the launch schedule.

SHEPARD You see we have the LM mockup, also.
You ought to get something out of being there. Once for each training cycle is enough to refresh you how to do it. Fire training is a pain.

ROOSA That was kind of fun, you know, out there playing around.

PLANETARIUM

SHEPARD I think that the level at which we use the planetarium is about right — for me anyway.

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MITCHELL I think the two or three trips we made over an 18-month training cycle was adequate. I think we ought to make those trips, and I was very pleased with the results.

SHEPARD I don't have any preference as to which is better — Griffith or Morehead — whichever is closer. I think the two are equally good as far as training is concerned. They have good instructors out there as well as at Morehead, so either one is good.

SIMULATOR TRAINING PLAN

SHEPARD Well, we told Riley's guys that we didn't want to be deciding what we should do in the simulator. They were the experts in training; they could tell us what we needed. If they left it up to us, we probably would end up doing more of what we wanted to do rather than what we should do. So, that's the way we played the game. I think they liked it that way, and I think it was more profitable to us to do it that way. It was just about one less decision for us to make. I recommend the subsequent crews leave it up to the simulator training people as to exactly what the crew should train on. They can tell pretty well what the crews need and what they don't need.

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SYSTEMS BRIEFINGS

ROOSA I guess we had just about enough of that.

SHEPARD I would like to make a comment on that. The briefing personnel whom we get out of North American are good. They are the ones who know the system. But even at this late date, we've still got a little reluctance on their part to brief totally from the FOD schematics. They spent years out there developing their own schematics and their own training guides. They will use the FOD schematics only if you insist on it. What I worry about is whether we are paying them extra money to keep up two sets of schematics and their briefing guides. If NASA is paying them any money for their own training material, they should discontinue that. That training should be strictly off the FOD schematics, nothing else. It is the only thing you will carry. You will come into a systems briefing and they will give you a big pile of their training booklets. If you had nothing else to do, I doubt if you still would ever get around to reading them anyway. Certainly under the training cycle press, you would never read these but would just put them off in the corner somewhere. It is another pile of paper that is wasted and,

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SHEPARD (CONT'D) I am afraid, money wasted. Those briefings should be conducted with the FOD schematics only, and NASA shouldn't be paying them any money for any other material.

MITCHELL I believe the LM briefing team used to be pretty good at Grumman. It has pretty much been disbanded. I doubt if there are more than one or two people left in the whole Grumman system who are adequate briefers for crews. I think we have found that we knew as much as the people they were trying to send down. They probably got pulled in on another job somewhere. The replacements weren't oriented towards our problems as well as the original people we had in the system. Whereas at one time they had some very excellent briefers, I guess with contractual problems they no longer maintain that group of people. The same comment applies about training from the FOD schematics. I believe those are the only schematics we really train from for systems briefings.

SHEPARD One more time -- I did not use the AOH.

ROOSA I want to comment on the AOH, too. Here again, if NASA is spending any money at all on that AOH, it ought to be discontinued. It's not only wasted money; in many cases the AOH is negative training. Volume 1 particularly is not up to date. You can get some wrong information out of it. Volume 1 should

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ROOSA
(CONT'D)

be totally discontinued. I personally don't see any use in Volume 2 either. I don't know if anybody uses that, but if we are spending any money on the AOH Volume 1 and 2, it is a complete and total waste. Hopefully, Skylab will not get bogged down in that sort of an operation, but that is probably already decided by now.

I think I got into a unique situation on the AOH last fall. Last fall, I came up with some time on my hands, recuperating. At that point, I had already had quite a few hundred hours in the simulator, and I decided I would just go back and read through the AOH. It was an absolute waste of time, and like I said before, in many cases was negative training.

MITCHELL What information is in there is definitely not oriented toward our needs. It might be oriented toward someone else's, but definitely not flight training.

ROOSA It is a waste of money.

TOPOGRAPHY TRAINING

SHEPHARD The next item is topography training. From my standpoint, it was primarily localized to the landing area. We didn't get too much general topography training, and so I won't comment on that until we get down to lunar surface training.

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ROOSA I certainly felt well trained in this area. You do have a single-point failure in the CMP's orbital science training in the form of Farouk El Bazz. He is the only one in the system who is adequate to train the CMP. Any lectures that I got, other than his, I didn't think too much of. His were extremely good. He has the talent to train the CMP. He also has a lot of other jobs. Tex Ward may have had some problems scheduling the exact times that we wanted, but I think we got most all our session in. They were extremely valuable. If the CMP works with Farouk he can essentially chuck the orbital map by the time he is ready to fly. I wouldn't waste too much time getting briefed by anybody else. We didn't work with Farouk too much on the landmark identification. The book that we make up on the landmarks is sufficient. My book of landmarks and the photomosaics that they had for them were extremely good. I'd studied them prior to flight, and during flight I could recognize them.

LUNAR SURFACE TRAINING

SHEPARD During the one-sixth g training, I used the KC-135 twice. We did not use the WIF or the POGO. I felt adequately prepared to cope with one-sixth g on the lunar surface. Quite a few one-g walkthroughs were made down at the Cape. I think the number that

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SHEPARD
(CONT'D)

we got was just about right. I just don't feel that a man in a pressure suit, working in a time line on the lunar surface can define minerals as well as he can in the lab. The same number of geology field trips but fewer classroom briefings would be a better geology training program. The SESL training was good, but the plain old altitude chamber run gives the man the confidence and the ability to go under a vacuum. The heat flux is not that great an addition to the training.

As far as briefings were concerned, I thought that the information we had from previous crews was good. The information we got from the field geologists, the PI types, was good.

MITCHELL

I would like to elaborate on the classroom training. As long as we are working under time constraints, like we're working under on lunar exploration, we ought to emphasize the things that are most useful: sampling techniques, and recognition of features that cameras don't show or that the geologists need in real-time to help real-time planning in the traverse. I think we were fairly effective in working with the field geologists to develop the descriptive technique and the thinking processes that allowed us to be flexible in real-time. This doesn't include much mineralogy and rock identification, et cetera. It was fundamentally the operational problem of how

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MITCHELL (CONT'D) you describe the terrain that you're seeing and bring back samples that will allow them to work for the next 2 years dissecting what you bring back. I think Jack Schmitt has done quite a bit of work in this area. His ideas should be listened to very strongly. I know he has encountered quite a bit of resistance earlier in getting that type of training.

CONTINGENCY EVT TRAINING

SHEPARD To continue with the EVT training. We did only two one-g walkthroughs for contingency EVT. We did it once integrated with the mockup and the CMS. I think one one-g walkthrough was sufficient. We did so damn much work with the suit in one-sixth g, I think that by the time you get to contingency EVT training, there is no problem.

EVA PREPARATION AND POST-TRAINING EQUIPMENT

SHEPARD For PREP and POST-EVA, I think we had just the right amount of training. Training equipment was good. It was supported very well. Scott Millican did a good job in that area.

MITCHELL We just flat wore out all our training equipment. It's a good indication that we had enough.

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EMU FAMILIARIZATION CHAMBER TRAINING

SHEPARD The EMU familiarization chamber I think should be a test before the vacuum chamber run.

MOCKUPS AND STOWAGE TRAINING EQUIPMENT

SHEPARD I thought that everything we did was good in the area of mockups and stowage. The command module mockup was excellent.

PHOTOGRAPHY AND CAMERA TRAINING EQUIPMENT

SHEPARD We didn't do too much camera training other than during specific exercises, and we didn't take the cameras home with us very much. Only on a couple of occasions, I think, you shot some from the T-38.

ROOSA I had one session in hand holding the 250 in the T-38 to get a little feel for the image motion, et cetera. Other than in the simulator, that's about the only time that I used them. I used them all the time in the simulators.

MITCHELL I think that, for my part of the lunar surface training exercises, it was quite adequate to practice putting film in the cameras, taking the pictures either on the field exercises or in the training exercises at the Cape, and then evaluating the film. Do this several times, and your camera training is quite

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MITCHELL (CONT'D) adequate. With each camera that you use, you should either mount it in the mockup if it's a fixed camera or mount it on your chest pack, if it's an EMU camera. Shoot enough film with it in the training exercise that you know what your field of view is and what to expect under the different conditions. When you've done that, I think you've done all you need to do.

ROOSA The cameras that I used in the CMS were actually the ones that I checked out as my own training cameras. The 16-mm in the CMS wouldn't work. You ought to be able to plug it in, watch the light come on, and when you click the shutters something should happen. So, actually, I put my 16-mm and 70-mm training cameras in the CMS and pretty well left them there. It seems that this is an item that probably should be assigned to the CMS.

LUNAR SURFACE EXPERIMENT TRAINING

SHEPARD We did a lot of the lunar surface experiment training with the ALSEP and also the additional experiments that we had. The LPM and the TDS training was adequate.

LUNAR LANDING (LLTV, LLTVS, AND LMS)

SHEPARD Well, I had the full course in the lunar landing training: the LLRF, the LLTV, LLTVS, and the LMS. I didn't get as much of a

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contribution from the LLRF certainly, but I did feel that the LLTV contributed to my overall ability to fly the LM during the landing; just how much is pretty hard to say. There is a value there somewhere, and certainly the handling quality is the same. We're reaching the stage now where the fidelity of the L&A is good. When you reach the point where you're re-training crews; then, maybe the return from the LLTV diminishes to some degree. About all I can say here is that I'm glad I had the experience of flying it, because I never felt at any time during the landing approach that I was out of control or in any situation that I couldn't handle. I felt like I could put that thing exactly where I wanted to put it.

PLANNING OF TRAINING AND TRAINING PROGRAM

SHEPARD The planning of the training and the training program was excellent. We appreciate the services of Tex Ward. He's a tough taskmaster, but he got us in good shape.

ROOSA Here, here. I think that here again it is a function of crew personalities, and we could spend probably an hour talking about details.

SHEPARD Monday morning I don't know how we'll look back over the things, but I think generally the comment is that it was great, and I think we ought to leave it at that.

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26.0 HUMAN FACTORS

SHEPARD I guess if you're stuck with it, certainly there's some - conditions which we were subjected to which were pleasant. It's nice living there in the crew quarters and they have all the facilities needed and it seems to me particularly, the compromise that you worked out with the medical people was good. I think it was certainly liveable. We spent lots of good time in the quarters and bearing down the backroad or over to the tank building. I didn't feel like I was fenced in by procedures at all. Whether it was that or the fact that we ate a lot of vitamin C, nobody showed up with any colds during the winter time down there. Well, we were all healthy at launch day. That's all that counts. We tried to back off a little bit during the last week. I personally didn't feel that we were run down at all when launch day came around. I don't know how you felt.

MITCHELL I felt great.

SHEPARD I thought everybody was in pretty good shape.

MITCHELL I'd like to comment that before our time line was relaxed a little bit prelaunch, I believe we had to exert quite a bit of effort to find time for exercise and to get adequate rest and sleep. It was not easy. And quite often we pushed

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(CONT'D)

ourselves in the simulators and at meetings to the point where it took a great deal of extra effort to get adequate exercise. I think each crew and the training coordinator ought to keep in mind, that exercise is an important part of training and time should be made available for you. You need to do it throughout the training cycle as well as the last 21 days. You really had to exert effort to go run at 8, 9, or 10 o'clock at night.

SHEPARD

As a crew, all decided to do the same thing. We went to low residue diets and went the bowel prep route. It was really effective for the first 2 or 3 days anyway. Some people held on longer than others. As a matter of fact, Ed almost made it through.

MITCHELL

Damn near.

SHEPARD

The last day was a loser, I'll tell you that. It is personal preference as to how you want to handle it. We all went the bowel prep, low residue route. It wasn't bad at all. We go to a lot of trouble to get crew preference preflight. I think everybody tries to be honest about this. I know Rita tries to come up with the best kind of a package deal. If that has been done, I'd want to go ahead and package the foods. The pantry is nice but for a flight like this, where you are busy most of the time making decisions, getting the food out of the pantry just takes up too much time. It would be my

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SHEPARD
(CONT'D)

preference to leave the pantry items for a flight where you have more time to sit down and relax. Then it may be nice to have to worry about what you're going to eat. From my point of view, I would prefer to go to the programed menu all the way. We decided ahead of time what we wanted and we bought off on the menus. I would prefer to see it programed. I prefer the wetpacks and the cans to the spoon/bowl packages. Here again, it's probably a function of room more than it is anything else. It was hard to keep putting those yellow pills in food waste. Since they decided that's the way you have to go, we went along with it. We ate just about everything there was to eat right on through TEI. Then I backed off a little bit. I'd made up my mind that I wasn't going to lose much weight on the flight, and I ate practically everything I had time to.

MITCHELL I didn't make up my mind about anything. I just ate everything that was in sight. So I didn't lose any weight to speak of.

ROOSA I have a couple of comments on food. I'm not a big eater. I did notice a drop off of my appetite in flight. I wasn't hungry and I couldn't eat all the food that was on the menu allotted for me. I'm kind of peculiar when it comes to eating. That big a variety of food doesn't appeal to me. I went over

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(CONT'D)

the menu prior to flight. In my case, I'd rather find a few things that I really like and stick with them. Maybe we made the wrong decision preflight. I personally preferred the cans, the bite-size food, and the wetpacks. If I could get all my food in those three forms, I think I would eat more. It was too much trouble to make up a spoon/bowl package and then I didn't particularly enjoy eating it. It was so much easier to open a can or open a package of the bite-size food. I would like less of the rehydratable foods. I think there should be an area somewhere, particularly for the 2 days that the CMP's in lunar orbit and is pretty busy, with cans and food in it so that you wouldn't have to open up a complete meal and then not get around, to eating it all. I couldn't eat a complete meal. You get your whole meal spread out and keep it corralled long enough to eat it and then you have to keep the empties corralled long enough to get the yellow pill in there. You can't just toss them in the garbage as you go along. That is a drag, but I don't know how to eliminate the problem.

MITCHELL I found that my appetite during the flight was pretty good. If anything, it was improved over preflight. Preflight, I'd been holding back and in flight I didn't bother about that. The food all tasted good to me. It even tasted better than I thought it had preflight. I agree with Al that my appetite

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MITCHELL (CONT'D) dropped off a little bit or maybe my preference changed a little bit after TEI. I wanted to snack more than I wanted to go to the trouble of preparing food. It wasn't that it didn't taste good, it just seemed to take too much effort. We still ate everything that was on the menu and then some. I also did not care to mess with the spoon/bowl packages or the spoons. I preferred to take the spoon/bowl packages, cut off the end, and eat it directly out of the package. I also liked the cans; they were very nice. The food was fresh, tasty, had a good flavor; it was easy to use. On the lunar surface, we both ate everything that was in the LM except for two packages. And that was only because we didn't have time to eat them.

SHEPARD The water was swell.

ROOSA Yes, I think so.

MITCHELL So do I.

MITCHELL We should keep programing the 8- to 10-hour sleep period each night. I found I didn't use it. I would get anxious by morning and ready to get the day underway because I couldn't sleep anymore. Some people might be able to sleep under those conditions, so we shouldn't shorten the period even though we're not getting that amount of sleep.

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SHEPARD Yes, you have to keep it in there. It keeps people on the ground quiet. If you have things you want to get caught up on at the end of the day, it gives you the opportunity to do it. You can't predict ahead of time what you're going to need to do. So, I think it is good to leave it in there. The restraints are good; no comments on those. We did exercise on the way out, except for the first day. I found that it did help relieve the muscle soreness, particularly in the back. On the way back, the first day we were tired and the second couple of days we did a little. We missed 1 day on the way up and 1 day on the way back, and I felt fine. As far as the surface crew is concerned, they got a hell of a lot of exercise running around and being in one-sixth g for 30 plus hours. They have an advantage with respect to inflight deterioration as opposed to the CMP. We didn't have any muscle soreness or any postflight problems. The tests show that the surface crew suffered less degradation for the work you do than the CMP. I think that has to be a factor of being able to exercise in the middle of the flight.

MITCHELL I'm sure it must be.

SHEPARD Do you want to comment further on that?

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ROOSA We tried to do it when we could, but I personally would try to exercise more on the next flight.

SHEPARD In flight, I thought oral hygiene was good. I used the toothbrushes, the toothpaste, and the dental floss at least once a day. Some days I used them twice a day and found it was satisfactory.

MITCHELL Let's say it's adequate. The toothpaste always improved the taste of your mouth, but since I'm not in the habit of swallowing the toothpaste to get it out of the way, it represents a change. That was adequate but I would hope, that on the future generations of spacecraft, we would do something to make that more like home. That's true for the whole business of hygiene and oral hygiene.

SHEPARD You could have gone over and sprayed it in the Myrtle if you'd wanted and flushed it out of the LM.

MITCHELL I'm afraid I would have missed and have it all over the spacecraft. I don't chew tobacco so my aim isn't very good.

SHEPARD I didn't use sunglasses. I used corrective lenses a couple of times.

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MITCHELL I never put mine on. There were times when I thought I was about to and then we would rotate from the Sun to another orientation and the problem went away. I never put mine on.

ROOSA I never had mine on at all. I was getting some pretty bright surfaces around the Zero Phase area, but I never felt the need for the sunglasses. I don't wear sunglasses very much normally.

SHEPARD Did anybody have any problems focusing?

ROOSA No.

MITCHELL No.

SHEPARD We've talked about up Sun versus downside on the lunar surface.

MITCHELL I think we've covered that area pretty well.

SHEPARD I had my visor up during the first part of the first EVA and then brought it down. I think it helps vision.

MITCHELL I brought mine down and left it down continuously. It is difficult to see in the shadows, but it's not that bad. You're not in the shadows that much.

SHEPARD You can always lift it. It's a very handy device.

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MITCHELL I thought the ballcap was very good. It's the most recent improvement we've had on the LEVAs.

SHEPARD We've covered judgment distance before. It's difficult to judge distance accurately on the surface.

Primarily as a function of atmosphere versus lack of atmosphere — visual acuity and that sort of thing. We have already talked about that.

SHEPARD I didn't have any eye irritations. Once in a while there would be some heavy airflow which would cause a little tearing because there was a lot of flow in the helmet.

ROOSA The only irritation I had was when I used the nose drops.

SHEPARD Poor Stu over-dosed himself.

MITCHELL The only irritation I had was when something floated into my eye. I blinked it back out in a couple of seconds. My eye was irritated for 20 to 30 minutes.

SHEPARD We used nose drops, that's all. We felt we were prepared to use what was there. We'd been properly instructed on everything. We didn't have the need for it. We were in pretty good shape for housekeeping. We commented in detail on that in the various phases of the flight, I think we can skip over

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SHEPARD that. Obviously Ed can't comment on shaving. We had that
(CONT'D) windup razor and I thought it easy to use.

MITCHELL I can comment on it for the first 3 days.

SHEPARD I found it easy to use; I said beforehand I was going to try
to compare it with the safety razor but I never did. You have
to clean it up with a wet tissue underneath when you're shaving
to keep your cut whiskers from floating out. When you didn't
do that, your cut whiskers would float up. When you did do
it, they would not. I recommend it. It's not a bad deal.
What do you think?

ROOSA It is more than adequate. I thought it was great. It is so
much easier than trying to get out the lather.

SHEPARD We talked about dust and the lack thereof. It was less of a
problem on our flight than it was on others. We've covered
the Personal Dosimeters.

ROOSA I tried the Survey Meter several times. I turned it down to
its lowest setting on the one-tenth scale and I would get a
reading of something like 0.00. That put it way down in the
decimal points. Essentially we had no reading on it.

SHEPARD We didn't use it when we were supposed to use it.

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ROOSA Yes, we did.

SHEPARD When we were at TLI plus 1 hour.

ROOSA No, I said as long as we were outside the radiation belt.
All the times we tried it, we were out of it.

SHEPARD Okay.

ROOSA After I talked about it, I said I would like to turn that on
going through the belt to see if we could get a reading.
I never got around to it. You don't have time at that attitude
to mess with it.

SHEPARD I thought the wipes were great. We used them.

Hot water and cold water certainly helped out. Everyone cer-
tainly used the tissues. Keep those tissues on there.

ROOSA You need a lot.

MITCHELL You sure do.

I don't feel quite as satisfied with the personal hygiene
setup as Al. I thought the wipes didn't have enough soap. I
would like to have had a little bit of soap to wash my hands
with, in addition to the wipes. We did use potable hot water
and a wet a towel to wipe down with. I did this several times

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(CONT'D)

during the flight. Somehow, just wiping off with pure water doesn't quite satisfy the problem. I would like to have been able to wipe down a little bit more with some soap and then maybe a sponge down with a towel. I think we can improve that situation a bit. I got as grimy, sweaty, and smelly as I expected to, but it improved my outlook on life a little bit when I was able to clean up a little.

Well, we reported all light flashes in real time.

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27.0 MISCELLANEOUS

MEDICAL REQUIREMENTS

ROOSA I have a comment on medical requirements preflight and post-flight. You are anxious to do anything that's necessary to get all the data for the flight. I hope they really used all the specimens they collected. As far as I'm concerned, it's a drag. Hauling all the bottles around isn't likable. If it's necessary, that's one thing; and if it's not, let's do away with it.

MITCHELL I have no additional comments on that. I thought that, provided they were well substantiated requirements, we would live with them very well even though they were a bloody nuisance.

SHEPARD I think that's the key to it. I think that the medics should be continually required to substantiate their requirements. I think their requirements should be just as documented as everyone else's. Once that's done and has been explained to the crew, that should take some of the bad taste out of your mouth. I still think they should be required to measure up to the mark just as everyone else does and adequately justify the sampling to be sure that it's not random.

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SHEPARD (CONT'D) We had no problems with the PAO. That was all worked out ahead of time. Even the people down at the Cape now certainly understand the name of the game. We weren't troubled too much with that.

MITCHELL I have one instance I'd like to mention. I think that when this little medical problem of mine came up right before flight that PAO was entirely out of line in demanding release of some of that information.

It had to come out of the medical shop somewhere. That's the sort of information I think should be classified. There's no reason for it to go to PAO.

SHEPARD I'm glad we decided to get out of the MQF the way we did. By the time we were ready to get out of that, it was a mess. We had the probe and the Hycon in there

MITCHELL And 108 pounds of rock.

SHEPARD And 108 pounds of extra rocks. There just wasn't room for anything else in there. By the time we got out, I was tickled to death to leave it.

ROOSA The MQF is designed for four, five, or six people to live in; and that's not the case when you're on board ship. You've

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ROOSA
(CONT'D) that many people living in it, but you have at least two people just working all the time. They have to bring all those samples in and there's no place to work except right in the aisle. You're all over each other in there.

MITCHELL In all due fairness, the two guys that were in there with us did one whale of a job.

SHEPARD Yes.

MITCHELL They did their job and let us get some sleep.

ROOSA They did a magnificent job.

SLAYTON What if you had to spend 7 more days in there?

ROOSA Oh, that would have been so bad!

SHEPARD Yes. There's no way they could have air locked out the probe and the camera. It was like having one extra person in there. Fortunately, we had the tunnel between the trailer and the spacecraft. We could walk out there during the day.

MITCHELL It helped to break the routine.

SHEPARD You had to look up at those little isinglass panels and talk to people. I thought it was quite comfortable, but obviously it's too long an operation.

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1. [REDACTED]

2. [REDACTED]

3. [REDACTED]

4. [REDACTED]