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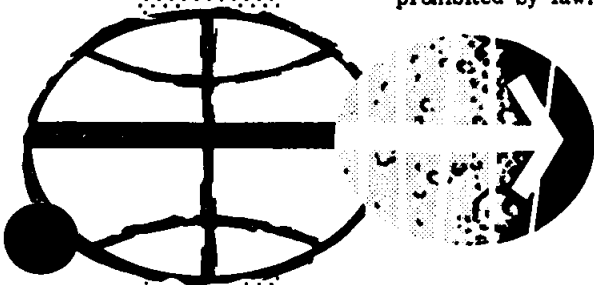
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PREPARED BY
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CREW TRAINING AND SIMULATION DIVISION

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1.0 SUITING AND INGRESS

SCOTT Starting out with the suiting and ingress, there were no problems. The suiting was on schedule, I think a little ahead of time. Ingress was nominal, and the cabin closeout looked good.

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2.0 STATUS CHECKS AND COUNTDOWN

SCOTT The communications were good. The countdown was smooth; I think we were probably 20 or 30 minutes ahead all the way. Can't think of any anomalies during the count. I thought the EDS checks went particularly well.

IRWIN I guess I was surprised that the hydrogen flow indicator on fuel cell 2 was out. I hadn't been briefed on that before the flight.

SCOTT Yes, that's right. That was a surprise. Nobody told us that. As soon as Jim called it, Skip came back and said, "that's right, it's out." Like you should have known it, I guess. Controls and displays were okay.

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3.0 POWERED FLIGHT

SCOTT My evaluation, compared to Apollo 9, was that the lift-off itself was softer and quieter. When the tiedowns went, we could feel definite motion, but it didn't seem like as much as it was on Apollo 9. The noise was relatively low-level, and none of us had any trouble with the comm at all. We had vibrations within the S-IC which were just about the same frequency as the noise you hear standing on the ground. You hear the reverberations from the engines or the S-IC vibrations were about the same frequency, low amplitude -- just something you could feel. Going through max q was noisy, but we still had good comm. And it didn't seem to me that that was as loud as it was on Apollo 9 either. I could hear Jim call cabin pressure relieving very clearly. You could hear pretty well all the way through there, too.

IRWIN Yes, I thought the comm was excellent.

SCOTT The staging was as we expected, I guess. It was what I'd call violent when the S-IC shuts down and everything uncoils there, and that was almost identical to Apollo 9. It was really just a big bang. We saw the fireball come up to the BPC; I saw it in my left side window. I saw the fireball out the front window, too.

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CONFIDENTIALSCOTT
(CONT'D)

Right after, or just prior to, the S-II ignition, there was a lateral motion, attitude-wise, in the vehicle. Sometime in this staging sequence, we got a slight yaw. The S-II was very smooth, and all the way through the S-II burn, we had a very light — I'd guess in talking about it — we figured 10- to 12-cycle-per-second vibration, something in that range, low-amplitude, something you could just feel, but it was continuous all the way through. There was no pogo, no change in the oscillation.

Tower jet was smooth and came away very cleanly. We didn't notice the PU shift; when we went through it, I couldn't feel anything. Could you, Jim? I remember on Apollo 9, we also didn't feel the PU shift, but I guess other crews have felt it.

The S-II to S-IVB staging was about a quarter to a fifth the force of the S-IC staging. It was again a positive kind of feeling, but it wasn't a violent crash like we felt on the S-IC, I didn't think. We had the same light 10- to 12-cps vibration on the S-IVB all the way into orbit. The shutdown was smooth.

All the sequences throughout the launch were nominal and as expected. All the lights worked good; controls and displays were good, comfortable.

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IRWIN The noise and the vibration were less than I was expecting; it was much less. I was impressed about the lateral vibration on launch. It was much greater, of course, on the S-IC than it was on the S-II. Just a shaking, back and forth, lateral vibration all the way through the launch. It was a pretty smooth ride.

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4.0 EARTH ORBIT AND SYSTEMS CHECKOUT

IRWIN The insertion parameters are here. I can't read them; my eyes are dilated.

SCOTT Okay. 93.2, 88.9, and I think the ground eventually had us in a 93 circular. But that's in the ball park. The post-insertion systems configuration and checks went very smoothly. I don't think we had any problems at all. We took our time. We spent about 10 minutes or so just looking at the scenery after we cleaned everything up with the gimbal motors and all.

IRWIN We had one secondary propulsion barber pole.

SCOTT Yes, that's right.

IRWIN Insertion B, B secondary, right?

SCOTT Yes, we set that and it went great. I had it written in this one too. RCS-B secondary isolation valve barber pole, cycle to gray. It didn't come on at insertion. It came on at some other point.

IRWIN Yes, we noticed it when we did the check.

SCOTT I have a note in here when you did the fuel cell purge check. You confirmed, there wasn't any H₂ flow. Of course, we knew that.

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IRWIN We didn't get the MASTER ALARM on the H₂.

SCOTT I have a note here. At about 53 minutes, we noted that the D primary and secondary RCS isolation valves were barber pole, and cycled them to gray. And with all that going on, I made an SM RCS minimum impulse check, just to make sure that the RCS was working okay. I did that at 01:00 g.e.t., and it worked fine. It was night and we could see the flashes. So I was fairly well convinced it was okay, that there wasn't any problem with it then. I don't remember what event would have triggered those barber poles unless somebody hit a switch, and nobody remembered hitting a switch. We talked about it, how did that thing get barber poled? When we noticed it, Al and I had been down in the LEB getting the helmet bags or something.

WORDEN Okay, you've already given your comments. I don't really have anything more to add, other than the fact that I guess the shaking of the S-IC was a little bit more than I expected. More lateral shaking, a little more vibration than I expected. right at lift-off. When we got away from the tower and got away, maybe from some ground effects, whatever it was, it smoothed down. After being briefed several times of what to expect at separation, it didn't seem as violent as I was really expecting it to be.

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SCOTT Which one?

WORDEN The first one.

SCOTT I thought you agreed that it was pretty violent.

WORDEN It was pretty violent, but I guess I was expecting something even more than that.

IRWIN You had us so well briefed, Dave, that we were expecting it.

WORDEN The guidance in the CMC was just dead-on, like what we looked at in simulation. I could almost repeat the numbers verbatim, because we had seen them so many times in simulation. It was just absolutely perfect, dead-on. The Z-torquing angle that we got after we got insertion was about half, as I recall, and that's just about what the first P52 showed, right in that ball park. We have the numbers written there somewhere, but the guidance was right-on, super. We had no problems at all with the alinement. In fact, that was generally true with all the alinements. The first alinement went very smoothly. Tracking it in ORB RATE was no problem. The Z-torquing angle came up about the same as they had called up.

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SCOTT UV photography.

IRWIN I don't know that we had a color mag out at that time.
I think we just had a UV mag out.

WORDEN I recall now, we did discuss that in flight. I think we decided that the color mag would be nice if we could get the same area that we had taken the UV pictures of. But we couldn't do that because of the time. It wasn't valuable taking a color of some spot other than where we had taken the UV.

SCOTT The attachment of the ORDEAL to the spacecraft was very loose.
I just couldn't believe it; the thing was really rattling.
Somebody ought to check that.

IRWIN The ORDEAL itself worked just fine.

SCOTT We had about a 1 hour check there. We did the attitude reference check at 01:28 g.e.t., so that was an hour and 20 minutes or so; and it drifted 2 degrees in pitch, 1 degree in roll, and about 1 degree in yaw. So, it was good confirmation on the SCS. Optics cover jettison. Did you see any debris?

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WORDEN Didn't see any debris. Didn't see anything through the optics when they went. All I heard was a slight thumping noise when the covers came off. That was it, never saw anything in the optics.

SCOTT Okay, COAS looked good, horizon check looked good, the S-IVB was driving very smoothly, ORDEAL was tracking right on. The whole launch vehicle was just super.

Unstowage went as planned. Comm was good. TLI preps were nominal.

Subjective reaction to weightlessness. I guess we might go into that one.

I had fullness of head as I expected to have. I had no other sensation whatsoever. On Apollo 9 I had felt some tendency not to want to move my head, but in this case I felt completely at ease. I noticed in looking around, that I felt quite well adapted immediately upon getting into orbit. I think that probably had to do with all the flying we did prior to the flight, the acrobatics and everything in the T-38. That's the one thing that I did different from Apollo 9. I really believe that was a help, because that was the only thing that was different. I felt much better this time than I had on Apollo 9.

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WORDEN I had the same thing, a little fullness in the head. But I never at any time noticed any problems with equilibrium,, sensation of spinning, or any problems with moving my head. The thought crossed my mind at the time that it was probably a result of zero-g flight. I was ready to move right away, get down in the LEB and get on with that part of it. Dave kept telling me to slow down a little bit. I think we both came to the conclusion that there wasn't really any reaction. We weren't getting any reaction out of it. We could proceed on normally after a few minutes.

SCOTT Yes, that's right. How did you feel, Jim?

IRWIN Well, I definitely had a fullness of head that persisted for 3 days. I had just a slight amount of vertigo. I didn't want to move my head very fast or move very fast in any direction. That was more pronounced, of course, once we got inserted. That feeling gradually subsided, but I still had a slight amount of vertigo, even after 3 days.

WORDEN I really felt like we were right at home when we got into orbit. I really felt very comfortable in the environment. Maybe that's part of it too. If you feel comfortable with that kind of environment, that may help you adapt more to it.

IRWIN I just didn't want to move very fast, but not nauseous.

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SCOTT That's the way I felt on Apollo 9. I just didn't want to go fast. It might just be the time of year, as far as anybody knows. But there were no problems.

As far as any other anomalies, I can't think of anything else prior to TLI. We were well ahead of the checklist all the way. We had plenty of time to look out the window and watch the scenery. We took in a couple of looks at the sunrise and the earth airglow and everything. I think the time line was well organized.

WORDEN As a matter of fact, I thought we had a lot more time in flight to just look out the windows, see the Earth and see what was going on, etc., than we ever had in simulation. The time line seemed to work out so much better, for some reason, that we really had additional time, and it just flowed so smoothly that we didn't miss anything in the checklist.

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5.0 TLI THROUGH S-IVB CLOSEOUT

SCOTT I'll go through the notes we wrote down in the Flight plan on TLI. The time base 6 events were on time. The one thing that I noticed, which was a fair surprise, was that the helium repress was very slow compared to the CMS. In the simulator, helium repress goes very rapidly, and pressure on the oxidizer tank comes right up. In this case, it came up very slowly. It was almost an imperceptible beginning. I called the ground and questioned them on it. They called back and said it was a normal repress. I think we ought to have the simulator people take a look at that. It was a little bit of concern even though we had the ambient bottle if we didn't have the repress. But in the back of my mind, I was wondering what was wrong, and nothing was wrong.

One minute after ignition on the S-IVB we had PU shift, which we hadn't been aware of and which we weren't expecting. We did feel a very noticeable change in thrust, and that hadn't been discussed preflight. It was something, I guess, we just missed along the way. It seemed strange to me that we didn't have it in our checklist or time line. We had the PU shift for launch, and I think it might be a nice thing to stick in the TLI time line also, just so you'll know it's going to happen. It's no big deal.

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SCOTT
(CONT'D)

The new procedures that Mike Wash worked out for the TLI, putting that automatic and manual together, were really good.

The ORDEAL setup was just right. The numbers came out just right, and ORDEAL track was right on zero until the last minute when the guidance starts trimming things out. Had we been required to fly a manual TLI, the ORDEAL would have been excellent because it really worked well.

WORDEN

That procedure is nice, too, because it is easy to keep up with. It is sequenced in the checklist so that there are plenty of check points in there so you can get everything squared away. It really works best.

SCOTT

Yes, if you ever had to step into a manual TLI, you could do it about any place and wouldn't be behind. I think you did a good job on that.

I guess we all felt that same low amplitude 10 or 12 cps vibration all the way through S-IVB burn, just like we did during the launch. And we got a call from the ground on, it seems to me, a 3-second-early shutdown.

WORDEN

One further thing on TLI. I guess we wrote them down in the Flight Plan, but the residuals on the CMC at the end of TLI were very close to zero. We wrote them down. The CMC kept very good track of the TLI burn.

I can't read them.

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SCOTT Oh, you have bad eyes?

WORDEN Yes, I still have bad eyes.

SCOTT Yes, it looks like we had 2 seconds before cutoff. You gave all these to the ground, didn't you?

IRWIN Right.

SCOTT That's all recorded. V_C was plus 145 and V_I was 35 599. You got a 35 614 written over here.

IRWIN Yes.

WORDEN That's probably what it was.

IRWIN That's right.

SCOTT DELTA- V_C was minus 14.9, which meant the EMS was tracking well, too.

WORDEN That's right. Everything was working.

SCOTT We got everything squared away in time to do the T&D. Al, why don't you comment on the T&D? I think that went pretty smoothly.

WORDEN Yes, as far as I'm concerned, the transposition and docking was just as nominal as it could be. We came off the S-IVB and did the SCS turnaround and then trimmed the final maneuver with

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WORDEN
(CONT'D)

the G&N. I guess I started translating in a little bit more slowly than would have been — may have been more comfortable if I had translated a little bit faster. And everything was nominal inside the spacecraft at the time. The only thing I noticed about T&D was that the different reaction you get from the spacecraft as opposed to the simulator. The reaction you get from the spacecraft is very positive. You put a little bit of thrust in translation, and you get it right away. You can see the rates right away, which is something you don't always see in the simulator. Outside of that, I thought the T&D was pretty nominal. We went right on in; docking was no problem. It went very smoothly; all the latches worked except one.

SCOTT

The procedures, coming off the S-IVB and turning around, put us in a very good relative position when we got around. It was just nicely positioned as to distance from the S-IVB. We weren't too far away and we weren't too close, just very comfortable.

The high-gain antenna worked right away. We cranked it up, turned it on, and went to the values set in the flight plan; and it worked fine.

Formation flight was no problem; transposition was no problem. In docking, you had to give a little squirt on the plus-X to get the capture latches engaged.

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WORDEN Yes, that's right. We came in the first time, and I could feel the probe contacting the drogue. We just sat there, and it just seemed to at least slow down any forward rate. When I felt that the closing rate had reached a minimum, I gave it a little squirt of X, and it went right in from there.

SCOTT Yes, I think there is the tendency to go in a little too slowly. On a dock, that could be compensated by a little plus-X when you got there.

WORDEN Yes.

SCOTT Once you gave it the plus-X, I was watching the talkbacks, and they flipped right in the barber pole. We retracted and cinched right on down and heard a good bang on the latch.

WORDEN That's very positive. Not only can you hear it, but you can feel it, too, when those latches go. You really know you are there.

IRWIN Number 3 was the one that wasn't latched. It took two strokes.

SCOTT Yes, that's right. All of them were locked up tight except number 3. It took two strokes to lock it. Could you see anything hanging from the LM?

WORDEN I didn't see a thing.

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SCOTT You mentioned the handling characteristics. Sunlight and CSM docking lights must have been okay.

WORDEN We didn't need the docking light. Everything was illuminated by the Sun. We didn't have any problems with shadow; no problem seeing the docking target. It was very clearly illuminated. We didn't use the docking lights.

SCOTT I guess we've got to go in and get the tunnel all configured, and that went according to plan. The extraction was a pretty good bang, wasn't it?

WORDEN Yes.

IRWIN Yes. It was more than I had expected.

SCOTT That's a pretty good thump when it goes off — those springs pushing out — but there was no question that we had had extraction. You could see the S-IVB going away, couldn't you? Or could you?

WORDEN No, I couldn't. Jim could. I couldn't see out my window. I watched the EMS, and when we first separated, the EMS counted up as I expected. When we turned around, the thing kind of backed down again. We started out at 100, and it went up to about 125 or 126. When we turned around, it was down to 99.2, 99.3, or something like that. So, the EMS was affected by the

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5-7

WORDEN (CONT'D) turnaround. As a matter of fact, during the whole TD procedure, I had the EMS set up and had the accelerometers turned on. I was in DELTA-V and normal, but I really didn't rely at all on the EMS for any indication of DELTA-V. I used strictly time on plus-X thrusters and only looked at the EMS as a backup. In fact, I don't even recall looking at it more than maybe once or twice during the T & D

SCOTT Yes, I think that's a good procedure, too, especially when you check and make sure you have all your isolation valves open.

WORDEN Yes.

SCOTT You could be pretty well sure that it is going to get you the DELTA-V you want. The pyros going off made pretty positive sounds. RCS, retraction: I guess we've hit all those. We got the camera on right at the docking point. I guess we didn't take any pictures of the ejection because there's nothing you can take pictures of.

WORDEN That's right.

SCOTT The next thing is attitude control and stability during and immediately after the SEP ejection. Did you notice anything?

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WORDEN Attitude control was very good. There was no problem with attitude control. We did the whole thing in G&N. We came off the S-IVB with the LM and did some minus X. After we got off we did our VERB 49 maneuver into the S-IVB viewing attitude. It took us some time to get around to that attitude because we had low rates loaded in the DAP. I thought that maneuver went very smoothly. No problem at all with the maneuver. As soon as we saw the S-IVB, we called the ground and told them that we had the S-IVB in sight and for them to aline and do their yaw maneuver.

SCOTT Then we gave them a GO, also, for their basic burn very soon thereafter. We were good and clear. There wasn't any problem with that in the basic burn. The basic burn was a very slow, low-thrust maneuver. We could see some of the propellant coming out. There was a very fine mist if you looked very carefully, and the S-IVB moved very slowly along it's plus X-axis. I rather expected a burn there — some sort of impulsive DELTA-V — but it was a very slow thing. It wouldn't be any problem getting out of its way if you were in its way. We have talked about SEP and evasive maneuvers. Our S-Band comm was good all the way.

WORDEN I thought it was superb comm the whole way.

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SCOTT Nothing there on the S-IVB yaw and evasive burns or on the S-IVB closeout. Workload and time lines. I thought that was a very well planned sequence of events. We were busy.

WORDEN I don't think we were ever overloaded during that time.

SCOTT That takes us up through all the S-IVB activities.

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6-1

6.0 TRANSLUNAR COAST

WORDEN I don't recall now whether we did one P52 or two P52s before we went to PTC REFSMMAT.

SCOTT We did two. I'd like to comment on one thing here in the Flight Plan. Every time you had two P52s due there was only one box to fill in the numbers, and I thought it would be handy to have two boxes.

WORDEN Yes. The second one is a starting point for the next series of drift checks.

SCOTT They have stars.

WORDEN I couldn't agree with you more, but I'm so conditioned to writing down the gyro torquing angles in any P52 that I write them down even if there isn't a box in there. I'm sure it might be helpful to go ahead and write them down. As a matter of fact, it does give an indication of performance of the IMU because it tells how the coarse aline is working; how accurately you're getting a coarse aline.

SCOTT They have a place in here for shaft angle and trunnion angle for the stars. Do you know why?

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WORDEN Yes. You go to SCS narrow deadband and do your first P52. Then you take shaft and trunnion angles on those two stars. You do your second P52 with an option 1, and then if you have any problem locating the star, you go to the shaft and trunnion angles because you're still there at the attitude. It's just a warm feeling kind of thing. You should see those same shaft and trunnion angles come up on the second P52 within the deadband of the SCS.

SCOTT Okay. Well, the torquing angles looked good. I felt we had a pretty good platform at that stage. Let's see, OPTICS CALIBRATION.

WORDEN We ran all the P23s the same way. We did an automatic maneuver to the optics calibration activity and then an optics calibration, which is the first part of the P23 series. We had no problems doing the optics calibration, and I don't recall now what the exact numbers were on the calibration, but they were within 3/1000ths of being zero. Then we did a VERB 49 maneuver to the P23 attitude so that we made sure we had a good view from the LM and that the subsequent star horizon sightings would be done at approximately the same attitude and the same roll angle. I thought P23s went very well. I used minimum impulse to control attitude while I was doing the P23s. With the LM on, minimum impulse was very slow in correcting any attitude errors

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6-3

WORDEN
(CONT'D)

that we had, but it was very positive, and there were certainly no problems with that particular mode of operation for P23s. Outside of recalibrating myself on which horizon I wanted to mark on, the P23s were quite straightforward.

Incidentally, I might add here, we haven't yet found out what the results of the P23s were. I felt that one of the biggest helps I had in doing the P23s was in flying the really accurate simulator at MIT, where they have very accurate calibration and good slides and they can tell you within tenths of kilometers what altitude you're marking on. I spent a good session with Ivan Johnson (MIT) doing nothing but P23s — all the way through the flight, right from translunar coast back into transearth coast. I thought the P23s in flight were very close to what we practiced in the simulator. I really had a fairly warm feeling about that P23 system.

SCOTT

I think the updates you were giving there, particularly on the way home, sort of verify that.

WORDEN

The command module simulator (CMS) is just not set up to do P23s accurately. There's just no way you can build that kind of procedure into that part of the simulator. The simulator is good for procedures, in that case; but, if you really want a fine calibration on the altitude, on the horizons you're looking at, and on your eyeball and what you're doing, then the MIT

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WORDEN simulator is the place to go, really. That's really a must.
(CONT'D)

I was really impressed with that whole thing.

SCOTT Yes. I really think you could have got us home.

WORDEN Yes. They kept telling us all the way home that our vector was as good as theirs.

SCOTT The next thing is SYSTEMS ANOMALIES. I guess the first one we noticed was the SPS THRUST light being on.

WORDEN I think I noticed that SPS light right after T&D.

SCOTT Yes.

WORDEN We were just sitting with nothing going on. The EMS was turned on, and I looked up and saw the SPS light on. That was fairly close after T&D.

SCOTT We went through the procedures, I think, which are already documented by the ground, as they recommended, and found that there was a short in the switch. I think pounding on the panel turned the light on for us, and finally, manipulating the switch gave us a constant light on. First time we tried it, I guess, we moved the switch up and the light went out. Then I played with the switch some and got familiar enough with the short that I could put the switch in the mid-position on the lower portion of the foreskirt and hold the light out. It

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SCOTT
(CONT'D)

would be interesting to see the inside of one of those switches some day to see if you could identify the contacts they're making. I think the ground did a fine job of coming up with procedures to evaluate the switch, and when we got down to checking the engine out, I thought the procedures they recommended were real good. They were simple, easy for us to change, easy for us to work through, and, in general, I thought that was a real fine bit of support they were showing on the ground.

WORDEN

That was superb, I thought. Like you say, the procedures were simple. It was very easy to make changes in the checklist, and the changes that they made were straightforward. It was a pretty straightforward systems problem, I think, at that point. The procedures that they recommended worked well for both the dual bank and single bank. You could just forget part of the procedure. All the burns that I did in lunar orbit, the short burns, I did on one bank only, so we would avoid any problem with that bank that had the short in it. The procedure was almost the same, and it worked out very nicely. The only change was in one extra circuit breaker that was out, the MAIN A pilot valve, in leaving the normal A DELTA-V thrust switch on.

SCOTT

I think we had a good, warm feeling that we had two complete SPS systems going into lunar orbit.

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WORDEN Sure did.

SCOTT Let's see, what else on the systems on the way out?

IRWIN Well, we had the AC problem on the circuit breaker, with the circuit breaker popping.

SCOTT Yes, I guess that popped, the lights went out, and we left it out.

WORDEN And we taped the rheostats.

SCOTT And, I think the only consequence of that was, as you mentioned, it sort of changed your pattern of operation down in the LEB because you didn't have the timer down there.

WORDEN We didn't have the mission timer down there, and the other thing that I missed in the LEB, which I found, I stubbed my toe on a few times, was that all of the program lights in the DSKY were out. The only thing we had was caution and warning panel down there. That was operational, but all of the status lights on the DSKY were out. They went with that circuit breaker. The backlighting in the EMS scroll was out. That was also off of that circuit breaker. I don't know if you want to comment on the backlighting on the EMS.

SCOTT It wasn't any problem.

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WORDEN I could see it all the way down. We didn't need the backlighting.

IRWIN The water system.

WORDEN Yes. The leak in the water system.

SCOTT Yes. I guess we can go through that one here. Was it the third night out when you were chlorinating?

IRWIN We were just getting ready to chlorinate. We had just taken the cap off when the leak appeared. I guess it had been leaking before that. But I don't know; it's hard to tell.

SCOTT It was found, subsequently, that Karl Henize had experienced the same type leak prelaunch, which is another thing we hadn't heard about. It would have been nice to have known that there was some sort of expected problem in the chlorination and how to take care of it before the problem occurred because I think all three of us were a little concerned when that thing started leaking at the rate it was leaking. It was really pouring out. I guess we'd just got the dump turned on to suck the stuff out. We were going to dump it overboard during the PTC when the ground came up with the procedure to tighten down that little valve in there. It was a very simple procedure, and had we known that it might occur, we could have taken care of it and saved a lot of anxiety and a lot of wet towels here.

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WORDEN Unfortunately, we looked for a break in the line. It's the chlorination part in panel 352, and that thing comes out of the panel, straight out, and then it angles; it has about a 45-degree angle on the vent and the first thought I had was that we had cracked that tube right there.

IRWIN You know, if we'd suspected that they'd had a problem before, we could have left the injector screwed on there so that it wouldn't have messed up that valve. Left it on there all the time.

SCOTT I don't think it was an injector problem, Jim.

IRWIN Well, I think you aggravate the situation by taking the injector valve off and on each time you chlorinate. You loosen that little valve.

SCOTT In looking at that little valve, it's a rubber seated valve. It seems to me that that wouldn't be a bad thing to take along as a spare because if you ever tore up that rubber seal there, you'd be in trouble. It was obvious that there's no way to check that off, because we closed everything. Al got out the systems book and we closed everything, and it turns out there's only one check valve between the potable tank and that valve there. And if you lost that check valve and the thing started leaking, it'd be all over. So I think, in summary, it would

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SCOTT
(CONT'D)

be good to know about those things, even if they do happen just before you go. If somebody could just pass the word and say, "Hey, we had a little trouble with the water system." And if you take a tool, B3 or whatever it was, and tighten it down, it would be just fine. But there were a few anxious moments there mopping up.

IRWIN

One other humorous note. You know, you were yelling for towels and I couldn't get into that compartment that had all the dry towels.

SLAYTON

You couldn't get into the compartment?

SCOTT

It was stuck and we got into it a little later.

WORDEN

Yes, we had a funny with the latch on that compartment, and once we got it open, it worked fine the rest of the time. I guess it was jammed. Something was jammed underneath that latch. You know, those are those radial latches, and the one under the head-end of the couch was jammed.

SCOTT

Those compartments are too big and they're not partitioned. Once you open one-half of one door, well, everything in there comes floating out unless it's tied down. To try and restrap things when you get through with them is a pretty good job because those straps aren't that easy to use. I think it would be very helpful if somebody could partition the various sections

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(CONT'D)

within the compartment with Beta cloth and a snap, or something, because we were forever and a day opening one of those things up to get one item out. Everything else came out and it was just floating, and, as you know, everything floats up plus-X-wise and you just have to leap on the whole compartment with all your arms and legs to hold everything down while you search for the one item you're wanting. They've grown to such large size, it's almost like having a whole aft bulkhead in one compartment. It was sort of a nagging problem all the way through. It just took that much more time.

WORDEN

Yes, it did. Those straps are very good at holding things down, but they're really designed to strap everything down pre-launch. They're not very well designed for use in flight. They have a very difficult little button fastener in them and the straps themselves have a rubberized feel to them that makes it hard to cinch those things down and get that little button into the loop. I agree with Dave. I think with compartments that large and with so many small pieces that we're fooling with inside the spacecraft, there ought to be some smaller compartments.

SCOTT

Every time you opened a compartment, everything just jumped right out at you.

IRWIN

Oh, yes. The screws on the restraint system came loose.

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WORDEN Yes. That was during the lunar orbit, but that's a good thing to mention so that we don't forget it.

IRWIN It's surprising in that it came out of the center seat and the right seat, both on the right side.

WORDEN On the right side, yes. The lower lap belt restraint attach point on the center seat and on the right seat came loose. The small bolts that hold them to the attach point and the nuts all came loose and just floated around. The lap belts came loose. I thought it was kind of funny in lunar orbit. When I took the center couch out, I noticed the attach point on the center couch was gone. And that strap was floating free. I looked around for the little bolt that goes in there, the little screw and the nut that goes in there, and I couldn't find it. I thought to myself at the time, well, I'll just sit and wait and sooner or later it will float by. Sure enough, all four pieces to that thing floated by: Two washers, a bolt and a nut. I just grabbed them as they went by and stuck them on a piece of tape. I kept the tape in one place and then put it all back together again. But I was really surprised that those little things came loose.

SCOTT I think it's a good idea to have restraint straps, especially if you're going to make a two-chute landing.

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WORDEN Yes.

IRWIN We were able to repair the one in the center couch because we got all the parts. On my couch, we never did find the nut for it.

WORDEN That's right.

IRWIN So we ended up just taping this good one up. And it withstood that two-chute impact.

WORDEN That little piece of gray tape.

SCOTT Yes. Take lots of gray tape.

WORDEN Best invention yet.

SCOTT Next thing is the MODES OF COMMUNICATIONS, and I think all of those worked very well. Super comm all the way.

WORDEN All the way. Fantastic tracking. We went to PTC attitude for the first time. We had arrived at PTC procedure preflight, which was different than the PTC procedures that had been used before because of the new universal tracking program. We didn't have the same kind of ORB RATE DAP that we had before. To make the thing work right we had to load 0.35 deg/sec in the rates and a half degree deadband into that, so that the thing would spin up when you first turned the DAP on. We got

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WORDEN
(CONT'D)

the attitude and used two adjacent quads to get the attitude to damp the rates. I'm trying to think now why. We eventually ended up getting the PTC going on the third try. On the first one the rates hadn't damped properly, I guess. When we got the PTC going, it wandered off. And on the second one, because of the half-degree deadband in the DAP, as soon as you get the first firing to spin the spacecraft up in PTC, you have to take CMC mode switch and go to FREE so that you don't get another firing from the DAP, which could give you some cross-coupling. As I recall, I hesitated, I didn't go from AUTO to FREE in one motion. I hesitated in HOLD just a second. That split second was just enough time for the thing to fire the jet, and it somehow got the roll rate screwed up because we drifted off attitude again. But I could definitely hear the jets firing when I went to HOLD. The third time, we finally got the thing started. We did everything just as per the checklist. The third try worked beautifully, and I guess it was one of the best PTCs we've seen. It worked just as advertised. And I don't think we ever had any trouble with PTC after that either. So it was just a question of getting that new procedure straightened out. The half-degree deadband was the big thing. We used to load 30-degree deadband in there and when you first proceed on the DAP you get a forced firing, which gives 80 percent of the rate that you loaded in. With

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WORDEN
(CONT'D)

the universal tracking now, that's all been changed and it doesn't work that way. So we had to go to the half-degree deadband. And it's just a question of getting used to that program, that's all. The P23s and the P52s were just absolutely nominal as far as I'm concerned.

SCOTT

Midcourse corrections. We did that one last midcourse prior to LOI to check out the engine to make sure that bank A worked okay. It worked exactly as advertised. It was a good burn.

WORDEN

That was a little bit humorous, in a way. We talked about that burn as a checkout of the SPS engine. And the procedure was that we'd get everything set up and we'd push that circuit breaker in, and, if the engine light was off, we'd then pull the circuit breaker right away. We got all the way through that burn before it really dawned on me that that was a midcourse correction. The DELTA-V we got out of the burn was exactly what they wanted on the midcourse correction. So it worked out rather nicely.

IRWIN

We did a lot of UV photography on the way out. In a way, that was good because we always maneuvered to a position where we could view the Earth or the Moon at the various stages.

WORDEN

The procedure that we established preflight to do the UV photography worked okay in flight — Putting the cardboard

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WORDEN
(CONT'D)

window shade up, pulling the Lexan shield down, and all that. But it's a cumbersome procedure, and we've got to be careful about a bunch of things all at the same time. You've got to juggle the camera and the Lexan shield and the cardboard and a whole bunch of things. I guess that's really my major complaint, the Lexan shield. That thing was fine the first day, maybe the first couple of days. But that Lexan is so soft and it scratches so easily that after a couple of days it was worthless as a window to take any photography out of. I sure hope that, if we do that kind of photography on the next flight, there's a better system of protecting the interior from ultraviolet than with Lexan.

IRWIN

The nominal mode was to leave the metal shield over the cardboard, leave the cardboard up all the time and leave the metal shield up. Then when we wanted to take the UV photography, just take the metal shield off. The cardboard was there. But that didn't work very well in lunar orbit.

WORDEN

That's right, because in SIM bay attitude, that particular window is the very one that you see almost all the targets out of. And you're sitting there with the Lexan shield in place, and you're trying to take pictures through it, and all you've got to do is touch it with a camera lens and it's scratched. I ended up using the Lexan shield as a shield, not

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WORDEN necessarily in the window, but putting it between myself
(CONT'D) and the surface and taking pictures around it, so that I could
get some decent pictures.

SCOTT The television cameras seemed to work okay.

WORDEN Yes. No problem.

SCOTT High gain antenna performance was all right. Daylight IMU
realine and star checking: You never had any trouble doing
alinements. They worked out fine. You want to comment on
your telescope? You didn't think you could see very much
through your telescope.

WORDEN Yes. The attenuation of the telescope. You really had to have
a very bright star to see it through that telescope. You sure
couldn't pick out any guide stars to any of the Apollo naviga-
tion stars, I didn't think.

SCOTT The light loss through the telescope seemed to be considerably
greater than Apollo 9. I could not see stars on the dark side
of the Earth very well through the telescope; and, on the dark
side of the Moon, I still couldn't see stars very well.

WORDEN It was absolutely amazing. You could look out the window and
the sky was just bright, there were so many stars. You looked
through the telescope and you could pick out maybe one or two

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WORDEN
(CONT'D)

major stars. That was all. A fantastic difference in the light attenuation through the windows as opposed to the telescope. It was unbelievable, really.

SCOTT

The CM/IM delta pressure seemed to work okay. When we pressurized the tunnel and did the latches, it worked as prescribed. Monitoring the delta pressure on the way out with the IM seemed to work all right. The IM and tunnel pressure were nominal.

IRWIN

Removing the tunnel hatch and the probe and the drogue was an order of magnitude easier than it's ever been in practice. It went exactly as we'd seen on the mockup over here. I thought it was a very easy operation. We put the hatch underneath the left-hand couch. We put the probe in the center couch, and lashed it down. We put the drogue underneath the left-hand couch and tied it down so that we had good clear access to the tunnel area. I thought the whole operation was very easy. No problem.

SCOTT

I thought we had a lot of odors in there.

IRWIN

I think it was probably due to all the hydrogen systems.

SCOTT

It cleared out pretty well. The spacecraft system cleared it out pretty well.

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IRWIN Not nearly as well as the LM system. Maybe that's just a function of three versus two guys. Of course, I was contributing my share too. I thought it was pretty gross in there.

SLAYTON What we are really searching for here is some sort of burn smell up there.

WORDEN Yes. I recall some powder smell in the tunnel.

IRWIN I didn't smell any nitrogen up there.

WORDEN I thought that whole tunnel operation was very clean.

SCOTT I think if you listened very carefully you could hear the SM RCS, and to me that seemed somewhat different from Apollo 9. I thought we could hear any firing fairly well on Apollo 9.

WORDEN On the service module RCS, I thought that the noise level of the solenoids operating on those RCS engines was much less than what we've got in the simulator.

IRWIN Could you really hear them or just feel them? I kind of got a muffled thud when they would go off.

WORDEN Yes, you do. It's very muffled though; it's very attenuated.

SCOTT I'd say it was almost an order of magnitude less that we felt on Apollo 9, as I remember. Maybe that's because it's biased by a lot of simulation noise, but you sure can't hear it very

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SCOTT
(CONT'D)

well. You can see it. You can see the flashes at night, but you sure can't hear much.

I think we all got the sleep as recorded. I think everybody slept fairly well. There were a couple of nights in there where I think everybody was really bedding down. That went quite well.

It seems like, particularly with the SIM bay, that we really never had enough time to do our housekeeping. We were always busy trying to keep up with things. I'm not sure whether it was because of the amount of equipment on board or because we had to constantly pay attention to our SIM bay operations.

But it seems like we were always pressed on the housekeeping. We had to eat fast, had to get ready for the next thing fast, and, in general, we never had a lot of time to sit around and wait to get to the Moon; nor did we have a lot of time to sit around and wait to get home. We always had something to do.

And it was mostly because the housekeeping took a fair amount of time.

One thing we all commented on was that it would be better if, when you awaken, you ate first and took care of your cleanup activities before you got into the operational part of the day. To try and combine operations with eating sort of compromised

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SCOTT
(CONT'D) both. A guy would be halfway through fixing a meal and he'd have to go turn on some SIM bay thing, which means you didn't do either one very efficiently. After waking up, you should eat, clean up and then go to work. You'd be more efficient. Is that what you were thinking of?

WORDEN Yes, precisely.

SCOTT There are a number of things you have to do in the spacecraft which aren't really called out in any time line. We have an eat period and then we have a rest period and vice versa. You can't go from an eat period to a rest period. There are a lot of things that have to be done, most of which are called out in the presleep checklist. You can't just go finish your dinner and in 2 minutes do the presleep checklist and go to bed. You have to have a transition period during which you chlorinate the water, change a canister, everybody take their last urination for the day, and clean things up in general. You have to have a period of time there to get ready to go to bed.

Another thing that's not mentioned that I think should be passed on is cleaning the screens with tape. I'm not sure that that's ever been discussed. I know we did it on Apollo 9. The suit circuit return screen and the screens on the suit

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SCOTT
(CONT'D) holders were constantly covered with stuff. You had to clean it at least once a day. It made a noticeable difference in cabin temp when we did that. The cabin was running sometimes up to 80 degrees. We'd clean those screens out and it would bring it back in.

IRWIN Also, the use of the cabin fan brought the temperature down. We couldn't find that other suit umbilical screen, so we had to improvise.

SCOTT This was on the way home.

IRWIN In conjunction with housekeeping, I think I'd have felt a lot more comfortable if we'd taken the time before the flight to decide where we were going to put everything, where we were going to put those Gemini bags, which CSCs we were going to use for garbage, et cetera. It wouldn't have taken very long. I would have liked to physically have used the Gemini bag and cleaned it up before the flight. It was always fouling up on me, and I wasn't transferring properly. Dave said, "Well, why don't you clean it?" I tried many times and finally, after about 5 or 6 days, I got it so it would work and I could clean it. But with little things like that, I got to the point where I just didn't want to urinate if it was that much trouble.

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WORDEN There are numerous things like that that you run into for the first time on the flight that you haven't really thought about before because they're kind of low in the order of priority. Just a quick briefing on those things would be helpful, but I do think that they're the kind of things that you pick up as you go along.

IRWIN If I'd just used the Gemini device once before the flight, I'd have gone into it prepared, knowing how to clean it and how to use it.

SCOTT I think we did make an attempt to get oriented on how to use the urine collection bags, which seemed to work out fairly well when we were restricted to one dump a day. That operation, although again it took a lot of time to get all the hoses hooked up right, did seem to work okay. But all the different devices you have to take care of while living up there required time and familiarization. I think both of you did try the defecation device before the mission. That wasn't bad; it was a job, but it still worked. I think your recommendation to take the UCTA and the UTSS and work them over before you go would be very helpful as far as time goes.

We had a lot of hydrogen in the water periodically. It didn't seem to be associated with any particular event. However, at some period after we used a lot of water, it seemed that there

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SCOTT
(CONT'D)

was a point at which the hydrogen increased in the water, and we got a lot of bubbles. And that was a problem, digesting all those bubbles. We tried the hydrogen separator and that didn't really seem to help very much. We also found that it didn't work on the food water tap; it only worked on the gun. We tried to consume all the meals as planned and maybe a little bit more. That means that when you eat a lot you have to defecate a lot. That meant that extra time was required to take care of those little chores.

Everybody stayed on an "as required schedule" and nobody would use any Lomotil. I think that was a good plan.

The biomed harnesses worked well. There are a few little things we might recommend for improvement, but putting them on and taking them off was a relatively simple matter. The data that they got on the ground was good. They told us before we went that the sponges which go into the sensors were going to be somewhat larger than the diameter of the sensor. They were not. They were smaller. We stuck it in and it would float back out. That was sort of a pain. They also have the sponges in little packages of two. We have five sensors on. This means that every time you put the five sensors on you have to throw one sponge away, because they're in packs of two.

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WORDEN Yes. But it gets darn important when you're in flight and you've got a package of eight of these sponges. I think they come in packages of eight. If you only use five of them, you've got three of them that you've got to do something with.

SCOTT Well, two of them you can put back and use again, because they're sealed in pairs.

WORDEN That's right.

SCOTT But the third one you've got to throw away.

WORDEN I'd like to add something else about the biomed sensors while we're on that subject, too. I think both you and I got a reaction from the paste or whatever was used on the disk on the biomed sensors. Now, I've still got some welts, some lesions, that I got off those biomed sensors.

SCOTT I'm not sure it was the paste or just the pressure of the sensor being on that same spot on my skin.

WORDEN Well, that could be. I'm just wondering if maybe there isn't something that could be looked into to see if there's a different kind of adhesive or something that would alleviate that problem.

SLAYTON Did they test you for allergy to that paste preflight as they are supposed to?

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SCOTT Yes.

WORDEN Yes.

SCOTT We wore it all preflight.

WORDEN Maybe you're right, Dave.

SCOTT We tried to put them exactly in the same spot on launch morning. Dr. Teegeen painted a circle on us where they had put those things. I redrew mine every once in a while, and it was very helpful. You just stuck them right where the mark was. And it was real easy to locate them there. But I think that doing it over and over sort of made you a little sensitive in that area. Al and I both have little rings there where the thing sort of cut in. But it was far better than wearing them all the time. I know that we could hardly wait to get ours off after we came up off the surface, because it was really getting irritable. I think that it was very beneficial to be able to take those things off and let your skin dry out.

I guess the next one I had here was our little Exergym. As we were on the way to the Moon, we were using the thing and trying to use it correctly, but it looked like the rope was wearing. There was quite a bit of fraying on the rope. So we decided that, instead of having everybody work out twice a day, to let

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SCOTT Al have it twice a day and Jim and I would do something else
(CONT'D) on the other time. That way Al would have the benefit of the
 thing.

WORDEN Well, I don't know what it's going to boil down to. The Exer-
 gym is good for keeping some muscle tone, but I found that
 there was just no way I could get a heart rate established and
 keep it going. There was just no way I could do that. So I
 finally decided on a combination of two exercises. I used the
 Exergym a little bit, just to keep my shoulders and arms toned,
 and I ran in place. I took the center couch out and wailed away
 with my legs, just like running in place as a matter of fact.
 I didn't say anything to the ground, but the doctors watching
 the biomed's called up and said, "Hey, you must be exercising.
 We can see your heart rate going up." And they kept me advised
 as to what my heart rate was. It worked out very nicely, I
 thought, because they could tell you that you're up to 130,
 going up to 140. Then I would exercise a little bit harder,
 and true, even though I wasn't exerting any pressure on any-
 thing, just moving the mass of your legs around really gets
 your heart going. I'm really convinced that that's the way
 to exercise in flight; get that kind of motion going and keep
 it going not let up on it at all. I did that for 15 to
 20 minutes at a time. I just ran in place as hard as I could.

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WORDEN
(CONT'D)

As a matter of fact, I thought I'd strained some muscles that I had never used before because I was just free wheeling my legs and wasn't exerting any pressure on anything. I really thought that was a useful exercise, and as far as cardiovascular was concerned, I thought that was a much better exercise than the Exergym. I used the Exergym just for muscle tone. I think it's good for that. It's a good thing. You can pull against that and it's almost like doing situps.

SCOTT

That's the best way to really keep yourself up to snuff up there, especially for people in the command module. They really don't have anything else. I guess our recommendation would be to get that small ergometer and put that onboard, because that's the only way you're going to get a dynamic exercise.

WORDEN

I found out that with the center couch out, there's just almost the right amount of room. In fact, the same thing could be done up in the tunnel area. You don't need a whole lot of space. In fact, that particular exercise doesn't take as much space total as does using the Exergym.

IRWIN

We strained against the struts, against the bulkhead, and against the straps; this was kind of an isometric form of exercise. I think it's almost as good as the Exergym.

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SCOTT You can put your feet on the bulkhead and hold onto the seat struts and do deep kneebends against your arms.

WORDEN In fact, Dave had the spacecraft moving all over every time he'd exercise. I'd sit there and watch the rates jumping up and down. He was really moving us around.

IRWIN As far as comfort is concerned, I think that after about 1 day out, we all took off the inflight coveralls. We got down to the CWGs and were very comfortable in CWGs until we got to the Moon. In fact, around the Moon, it was even warmer. It was almost too warm to wear the inflight coveralls, and it didn't really cool off until we got back to about 1 day out from the Earth.

SCOTT It seemed to be warm in the spacecraft. And I think we felt warm around the Moon, so we all just wore CWGs. It would have been too warm to wear the coveralls. On the way back, it really cooled off; the last day in particular. We were pretty chilly when we woke up the last morning in our coveralls, CWGs, and in the sleeping bag. We were down to about 65 on the cabin temp. But on the way out, in the vicinity of the Moon, we were running 75 to 78 in the cabin temp; I think that it was a fairly warm environment. It would have been nice to have been a little cooler. That was with the cabin fan on and everything.

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IRWIN And, in conjunction with that, it might be useful to have some pockets on the CWG if you get down to that mode. Then, you can have your pencils where you can get to them.

SCOTT That's a good point.

IRWIN Also, under anomalies, we ought to mention the problem with the cabin fan and whatever that loose object that was in there and the fact that we couldn't cycle it freely. We were afraid to turn it off because it might not start up again.

SCOTT And there was some piece of metal somewhere in the cabin fan. This jumps down a little farther along the line, but after lunar orbit docking and attempting to get the cabin cleaned out with all the lunar dirt and everything, Al heard a couple of clicks in the fan and then it picked up whatever it was and really started to groan. And then, there was a low-frequency, very hard vibration. We turned the cabin fan off and on several times and finally got whatever it was to lodge into a corner somewhere and the fan ran cleaner; but whenever we subsequently turned the fan off, we'd have to go through a couple of cycles to get the foreign object to relodge in a corner to get a clean run on the fan. There was something in there.

WORDEN It was funny. You could hear the fan running free - I mean running as it would normally - and then you could hear a ping

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WORDEN
(CONT'D)

just as if you'd thrown a piece of metal into the fan and it got picked up by one of the blades. Then you'd hear it rattle around in there and then you'd hear this groaning sound where it obviously caught in there.

IRWIN

Well, I'm wondering if the filter for the cabin fan shouldn't be a smaller mesh to prevent an object from getting in there to interfere with the fan operation.

SCOTT

You know, we recommended that for Apollo 9; that they put a screen in there so you couldn't have something drift down into the blades. And the blades are wide open to the cabin. If you have a loose nut or bolt or anything floating around when the cabin fan is not running, it can float right down into the blades. You ought to have some protection in there, or put the cabin fan filter up right away to keep it clean. You really need the cabin fan after a docking.

IRWIN

Of course, we don't know whether that object came in through the outlet or the inlet. It could have come in the inlet. That's a pretty wide mesh.

SCOTT

Anything else on housekeeping? The last thing in this section is the SIM door jettison. In general, that was a very light bump. You could hardly feel it. I think there's no need to suit up in the future. However, I think the suiting operation

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SCOTT
(CONT'D)

was a good exercise, because it gave us a chance to run through the descent time line. What we had planned to do was to wake up and suit up in the order in which we do it during the descent day to make sure we didn't have any problems and to see what the time line looked like. And I think we learned a few things in doing that suitup in zero-g, which Jim and I had never done in the 7LB. We learned a few things and I think it helped us on descent day to get a little ahead of the time line. But as far as a requirement, would you both agree that I don't think there's any requirement to be suited to to blow the SIM door? It's just not that big a shock. It was the lightest pyro charge by far of anything we had. Jim took photos of it.

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7.0 LOI, DOI, LUNAR MODULE CHECKOUT

SCOTT We discussed the procedures which were unique to the SPS, and I suppose we should talk about the LOI first. That was a pretty novel burn. It all worked out pretty much as we had seen in the simulator. The only surprising things about the burn were the residuals, all of which were zero. At that point, we were convinced we had a pretty good guidance system. No trim. It was a very smooth burn. Everything worked as advertised. Do you have anything else on that?

WORDEN No, I was impressed with the smoothness with which the engine came on and the smoothness with which the guidance worked. There were no abrupt changes; the gimbal motors were very smooth. It did jump around very, very slightly, but there were no big oscillations. We were right on trim when the burn started. The procedures worked fine. At 5 seconds after ignition, I pushed the circuit breaker in, and we got the second bank on. I could see the chamber pressure come up an estimated 3 percent when the second bank came on. It gave us a positive indication of the bank coming on. We pulled the circuit breaker 10 seconds before cutoff, and it shut down right on time. Dave was ready on the switches to shut down at the burn time plus 10 seconds. The burn was terminated automatically and, like Dave says, no residuals.

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IRWIN I think you got that circuit breaker at 6 minutes.

SCOTT That was the 6-minute call. That's right.

IRWIN As for the PUGS operation, the unbalance was in normal and stayed constant at about minus 200 until crossover. After crossover, it started to increase out of the green band, so I had to give it a decrease and brought it back to normal. It looked like it needed the decrease position and was left in the decrease position for the remainder of the burn.

SCOTT That put us in a pretty nice lunar orbit. We enjoyed the scenery and had plenty of time to get ready for DOI, and I think that's a great idea. You do the first rev to take a look at what is there. The time line was very smooth with no problems, and we got ready for the DOI. The DOI was again a nominal burn. We shut down on time manually, but the G&N beat us to it. I guess, Al, you could see I put my hands on the switches and timed it. When the time ran out, I put the switches down. Al could watch the PC, and I guess he saw it. Why don't you just say what you saw?

WORDEN Well, I heard Jim counting down. I knew Dave was ready to throw the switches, and just as his hand started to move, the PC dropped off. So the automatic shutdown and Dave's shutdown

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WORDEN
(CONT'D)

were almost simultaneous; except the automatic shutdown was, I think, just before his. It was perfect.

SCOTT

One of the things I might mention that is different from the simulator is that we always use PC in the simulator for our cue to start. In the real world, a physiological cue is far better. I mean you don't have to look at the PC to know when to start the watch. When it comes on, it is on; and you know darn well the engine is on. When it is off, it is off; and you know it. That is something you cannot possibly simulate, but that is something to be aware of.

IRWIN

I might make a comment in that connection, Dave. The valve indicator actually opened about one-half second before I got any physical sensation that they were burning. I would see it move, and a fraction of a second later, I could feel the light off.

SCOTT

I think you mentioned that during the burn. After LOI, you mentioned it.

I took a stop watch along because we were timing it in tenths of seconds, as I said was necessary for DOI. I think that unless you really have a double failure, you can't get in trouble on DOI. I don't think that is the problem that some people might have thought it was some time ago. That is a

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SCOTT
(CONT'D) good solid method of getting into a low orbit. Very little chance I think of getting into a bail-out situation.

Sounds SPS. I don't think we heard anything other than the force of the engine coming on. You couldn't hear anything.

IRWIN During DOI, it was left in the decrease position. For such a short burn, of course, it wouldn't stabilize anyway; so it was just left in a decrease position. I guess that after that burn, it was put back in the normal position and was left there for the other burns.

SCOTT Gravitational effects on spacecraft attitude. I'm not sure we ever noted any because we were always in some prescribed ORB rate or the SIM bay attitude.

WORDEN That is correct. We never really went out of an ORB rate maneuver. We were either straight heads down, straight heads up, or in SIM bay attitude.

I guess that was true continuously throughout the lunar orbit. I don't think we ever went out of that particular attitude except for the rendezvous. My hat is off to the people who designed the DAP because that just worked so smoothly it was almost unreal. It was so smooth all the way around you never noticed the thruster firings. We stayed right in the ORB rate attitude all the time.

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SCOTT The confidence factor in the RCS goes up by orders of magnitude every day to the point where I think some of the training we do on RCS failures might be superfluous, because everybody powers down and goes to sleep. I guess my confidence factor on those jets is 100 percent. I don't think we ever worry about a jet failing on or failing off because you could hardly do the mission and have to worry about that. We were running through the ORB rate during the sleep, and they weren't bothering anybody.

WORDEN That's right. As a matter of fact, during the sleep periods, I don't recall hearing a thruster fire or any maneuvers at all.

SCOTT I don't either.

WORDEN It was just as quiet as it could be the whole time.

IRWIN It would be interesting to compare notes with the doctors. I thought I was getting a fairly good night's sleep; but I talked to the doctors this morning, and they said that wasn't necessarily true. It might be because I normally move around when I sleep (change positions), and they might interpret that as loss of sleep or loss of rest.

SCOTT SIM experiment prep was standard procedure.

IRWIN It was cook book.

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SCOTT Communications were excellent. PGA donning: We set up a plan on the LOI day to try out our sequence of suiting for PDI day. As a result, we changed our minds on PDI day to make it a little bit more efficient.

WORDEN You two put your suits on and then went into the LM to zip them up.

SCOTT Because it's a lot easier zipping up the 7 lb suits in the LM and it gave us a chance to do the tunnel work shirtsleeve. We helped you (CMP) get your suit on. It is worth while to run through suit donning because the first day we did it we had you (CMP) put your suit on. Then we put our (CDR & LMP) suits on in the command module, and it is hard to zip them up in the command module. That was a sort of chore. Jim suggested we suit up and go to the LM before zipping them up. That made it a lot easier. We recommend cleaning the tunnel out or putting the suits on unzipped, cleaning the tunnel out, and then the CDR and LMP transferring to the LM to do their suit zip. It would be a good idea to have a little trial run one of the days on the way out.

WORDEN As to the time line, that works out much better, too, because while you were over there putting suits on and zipping them up, that gave me a chance to put my suit on which is done in parallel rather than sequentially.

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SCOTT In general, there were no problems in donning the suits. Tunnel mechanics went very smoothly, as Al previously stated. We did it the same way on PDI day as to where we put the equipment. The hatch and the drogue went in the left couch, and the probe went up at the head of the center couch. IVT to the LM was straightforward. I guess we didn't observe the condition of the CSM thermal coating.

IRWIN LM status checks. The first thing we noticed when we got in the LM was the fact that the glass was broken on the tape meter. That initiated a requirement to clean up as much glass as possible. We transferred over the vacuum cleaner and started cleaning it up. That was the only anomaly we noted on housekeeping day.

I guess we might have gone through the comm checks too fast for the ground because they asked us to go in again so they could look at the battery operation.

SCOTT We will have to ask them, but I think they just wanted to get another data point on the battery. We found that we could run through the time line much faster on the comm checks than was allocated in the checklist. So, I guess that we didn't have the batteries on as long as they expected us to because it

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SCOTT
(CONT'D)

just didn't take that long to make the checkout. There is another factor we might mention. Having the LM housekeeping day moved up a day, or the day after TLI, gave them a chance to do all that testing on the tape meter. That gave me a warm feeling to know that they checked the thing out and it would work with a broken outer pane of glass.

I think it is a good idea to go take a look at the LM early and analyze your problems and get a good handle on them before you get too far down the road. Then if they do want to take another look at batteries, the second housekeeping day is no problem. It is nice to go back to the LM and take another look around anyway. We got another chance to clean up some more glass. We did find a number of pieces on the second day. I think we got most of the glass cleaned up; don't you, Jim?

IRWIN

Yes, I think the use of the vacuum cleaner from the CM was probably just as effective or more effective than the LM cabin thing.

SCOTT

The comm check worked well. Transfer of equipment worked well. I am glad we had that preflight training exercise to get all that equipment transfer laid out. That went rather smoothly. Housekeeping was nominal, and the power transfer back and forth from the CM to the LM worked as prescribed.

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IRWIN There was one thing that we did not do, and that was to take the water bags out of their stowage bags. We left them stowed. We couldn't see any reason to cut them open and take them out of the stowage bags.

SCOTT As we went through activation, we were always 10 to 15 minutes ahead of schedule.

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8.0 LUNAR MODULE ACTIVATION THROUGH SEPARATION

SCOTT The power transfer was nominal.

WORDEN Tunnel closeout was just as per the decal in the tunnel. Just follow that down step by step.

I guess there was an anomaly that happened during maneuvering to an undocking attitude. I checked things off on the Flight Plan as we went. We went right down the line on the Flight Plan and the checklist. We released the docking latch, put the suit on, and did a suit circuit integrity check. We installed the hatch, got a LM/CM DELTA-P, and went right on down the time line. We did a VERB 49 maneuver to the undocking attitude and the SEP attitude, went into P41 SCS and the whole thing. We went through the undocking checklist and got the probe circuit breakers in. I guess the major thing is that everything was nominal, except when I went to RELEASE on the probe EXTEND/RELEASE switch; nothing happened. Nothing.

I rechecked the circuit breakers and hit the EXTEND switch again, but nothing happened. At that point, there wasn't anything I could check inside. The only two things that you've got are the circuit breakers and the switch. So, I figured that there had to be something back in the tunnel. I went back and pressurized the tunnel. I looked in the tunnel

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WORDEN
(CONT'D)

and there was nothing there that was out of order. So I thought I'd go ahead and check those connectors again. I pulled the connectors off and put them back on. I figured that if that wasn't it then we had a serious problem. I put the hatch back in, depressurized the tunnel, and went through the checklist again, depressurizing the tunnel. We got a new attitude from the ground, which was the local vertical attitude. That time it worked fine. That's really a mystery to me.

SCOTT

We got a couple of good calls from the ground on that, one when we came around the corner. I called and told them we had not had accept and that you were in the tunnel checking the umbilicals. Right away they came back and said they had no TM on the program, which gave them the indication that there was something loose on the umbilicals, and that was, of course, the last thing to check. Soon after you checked everything they reported getting their TM, so that was a pretty good confirmation that that was the problem. Then, I thought another good call was immediately or very soon after. They came up and said no problem on the time, that we had 40 minutes to get the SEP done and just go to the local vertical attitude, somewhere around there, which was a big help to us. Jim and I were trying to plan ahead to make sure we didn't get too far behind the time line and get hooked into

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8-3

SCOTT (CONT'D) having to delay PDI rev. We were trying to plan our next series of events for a late separation. It was nice to have that call, to know that we had 40 minutes to get things squared away and move on.

WORDEN The MCC-H came up with an attitude after you'd requested that they give us the time and an attitude. We went to that attitude and we were there 4 or 5 minutes before the time. It worked out fine.

SCOTT I thought that was a very good recovery for an off-nominal situation.

SLAYTON It sounds like you guys were ahead of it, though, by the time you came around the corner.

WORDEN Yes, that's right. There was only one way to go.

SCOTT You check the switches and the circuit breakers, and the next thing you have to do is go into the tunnel.

WORDEN Anyway, we got undocked and from there on it went pretty well, except that the undocking was too late to do that low altitude P24. So we skipped that.

SCOTT You didn't do any formation flight; you went to the SEP maneuver.

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WORDEN That's right.

SCOTT You gave us a good call on gear down.

WORDEN Right.

SCOTT Which was nice to hear. I guess, you didn't see anything hanging from the LM that looked funny?

WORDEN No. The LM was clean.

SCOTT You didn't have any calibrations, did you?

WORDEN No. As a matter of fact, that was all supporting the things that you were doing. We got the pads for the P24, which we did in the next rev.

SCOTT Okay. You gave us a good call on your transponder, and I think that's a good sequence of events. We checked out the radar in the LM, and right afterwards Al gave us a call on the transponder. He checked his transponder right away. I think that's a good series, because that gave us a warm feeling about that whole system. I like the way he did that.

WORDEN The circularization burn was exciting, but it was perfectly nominal. They had updated the short burn constants for the engine characteristics. And the circularization burn was done on Bank B only, because of the problem we had with the SPS.

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WORDEN
(CONT'D)

I went to attitude. All the star checks worked fine. The burn was done on time, and the residuals were 00 and minus 0.5, which is a no-trim kind of maneuver. So that was perfect. It put us in a 65.2 by 54.8, and in fact, the circularization burn was absolutely nominal. It was a very nice burn, very smooth, and is sure a difference when you get the LM off. You can really feel that mother go. It's really quite impressive.

IRWIN All the fuel cell purges were nominal.

WORDEN We always got a MASTER CAUTION on fuel cell 3, and that was about all.

IRWIN We normally do on the H₂.

We weren't getting it toward the end.

WORDEN No, we weren't, as a matter of fact.

IRWIN It cured itself for some reason.

Early in the flight, when we purged the O₂ on fuel cell 3 we'd get the MASTER ALARM, which we should not have. Then, toward the end of the flight, that did not occur.

SCOTT Okay. We'll go through the LM side of the undocking and SEP. I guess on the separation maneuver, we got about a tenth of a foot per second. Wasn't that what it was in P47?

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IRWIN I didn't write it down. Before we get there we ought to talk about the anomalies we had or surprises during the activation.

SCOTT Okay. Why don't you go through the stuff up to SEP.

IRWIN The first one was when you brought up the computer. We got a PROGRAM ALARM on the 1105, which was something I don't think we'd ever seen before.

SCOTT Yes. We had a lot of up link/down link too fast in the LGC. We got that several times, 1103s and 1105s, and I don't really know why.

IRWIN That's a good point.

But it's an inconsequential alarm, I think. We mentioned it to the ground and they never seemed to say anything. As I mentioned before, we were always 10 or 15 minutes ahead of time. I don't think we were ever really rushed there. Your alinement went real well. You didn't have any trouble seeing the stars.

SCOTT Yes, I did too. I had a tough time seeing Dabih. Dabih was a good star as far as position goes, but it was a very difficult star to see as far as alinement goes. If you can pick out bright stars, it'll sure help you. I guess the message there is, even if you don't have a NAV star, I think I'd ensure I

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SCOTT had a good bright star for those alinements through the AOT.
(CONT'D) But the alinement went very well. The P57 docked is a very practical technique. You get a good alinement out of it, and subsequent drift checks showed that we had a good platform. I think that's the way to go, rather than a docked IMU aline.

IRWIN The next surprise, and it was probably our biggest surprise of the activation, was the pressure integrity check. When we obviously did not have integrity, we tried going to the secondary canister and still didn't have any integrity. We decided to press on through it and do the rate check, which we did. Then, later on, I guess it was about 10 minutes before undocking, we came back and redid the pressure integrity check. Of course, we cycled through it right from the start; and this time, it worked out great. I think we had a 1/10th drop in 1 minute.

SCOTT I guess on the first one, we had something like 1 psi drop in 1 minute, didn't we?

IRWIN Yes. It was obviously something open, and I don't know whether the valve was just not seating properly or just what it was.

SCOTT Okay, you cycled the valve back there several times. We both fiddled with the detent and had a good detent in it, but couldn't come up with an answer.

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IRWIN Well, I guess the ground never came back to us with anymore words on it either.

SCOTT There was a question in my mind as to what the mission rule was at that time. I guess the mission rule was to undock and press on, which we were going to do had we not gotten a good check. But it was a good thing we started that check a little early. It gave us a chance to come around and do it again. The message is to get ahead and stay ahead; that's why we stayed 10 to 15 minutes ahead. Every time we got to a point in the time line where we could do something, we went ahead and did it, even though it was a little early.

We got a tenth of a foot per second on the undocking, and I trimmed that out on P47. The comm was good. On the PGNS activation self-test. You mentioned the ALARM. Everything else went well. How about going through the AGS, Jim.

IRWIN We didn't do AGS, of course, until after we had undocked. That was about an hour later. AGS was unpowered until later.

SCOTT We'll pick up the AGS activation in sequence. The landing gear deployment was positive, and Al gave us a good check when we undocked. The DAP loads were fine. Rendezvous radar and landing radar checked out as per checklist. The tape meter

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SCOTT
(CONT'D) worked just like it was supposed to, even though the glass was broken. The next thing is landing site photography.

As I remembered, you took some pictures as we went over the landing site. Incidentally, they came out very well, and so did the pictures of the command module.

IRWIN How about the sequence camera? We had the sequence camera on there, too. I guess we did have moisture on the IM windows, and we had to turn the window heaters on. I think it was fortuitous that Al had delayed the undocking until our windows cleared, so we could get good pictures of that operation. They were cleared up at just about that time.

SCOTT Well, I think Al wanted pictures of himself. He wouldn't have gotten them if we had undocked on time. He would have gotten a bunch of fog. I guess I'd like to go back to REV 10 and discuss something that's not in the debriefing.

IRWIN You mean looking at the landing sites through the sextant?

SCOTT One of the questions on the landing site was general terrain relative to boulders, debris, and craters. A couple of months before the flight, we had worked out a plan whereby we do the low altitude landmark tracking technique without the spacecraft rate drive in order to take a look at the landmark through the

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CONFIDENTIALSCOTT
(CONT'D)

sextant. There had been some question as to whether or not we could see anything. I took a look on REV 10, and it was as we had expected based on previous flights and fidelity of the optics. I could see the landing site very well. I could see Index Crater and the rille very well. I determined that there was no problem relative to boulders and debris, and it looked pretty smooth and flat. It was a comforting feeling to know that we wouldn't have a rockpile to land in. If the advertised resolution of 3 feet was correct, we had no problem with boulders on the order of 3 feet and above. This was subsequently verified when we got there. It was a nice thing to have behind us in the way of validating the surface at the landing site because of the poor resolution of photography we had from Orbiter. The technique worked very well. It was easy to track in Inertial Attitude. I think you found that during your J-1 track, also, didn't you Al? I think you could have done your landmark tracking without a spacecraft rate drive.

WORDEN

I almost feel that way, yes. The J-1 tracking was really easy. With a high rate in the optics, it was fairly easy to track if it was off track. You have some roll in there, so that you're not coming through zero on the track.

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SCOTT But the optics are very easy to control, have very positive response, and once you lock on the target, you can stay right on it.

WORDEN That's right.

SCOTT That gets us down to lunar landmark recognition. Of course, the landing site at Hadley was particularly unique, when relative to landmarks. When I looked at it through the optics, I could recognize the craters that lead into Index and Index Crater quite well, even though there didn't seem to be as many shadows, crater shadows, as I had expected.

MSFN Relay seemed to work all right.

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9.0 SEPARATION THROUGH LM TOUCHDOWN

WORDEN I want to say something about the VHF tracking. Of course, we didn't do any optics tracking prior to touchdown, but we did check out the VHF against the rendezvous radar. I think I reset the VHF three times, and it came up each time with half the value that the rendezvous radar had in it. This made me wonder at the time how good the VHF was operating, and it subsequently turned out that it was operating just fine. I don't know what caused the difference in the range between the rendezvous radar and the VHF at that close range, because it was 0.79 mile, or something less than a mile, I think.

SCOTT Yes, we had on the NOUN 78. In the LGC, we had 0.78; you had 0.4; and the tape meter had 0.78. Of course, the NOUN 78 is just a tape meter readout, but you did have, for some strange reason, just half value.

WORDEN I reset that thing three times, and I think it came up with the same value each time.

SCOTT I might add, in the LM, we could tell when you were resetting. It was audible, so we tried to observe a no-comm silence period while you were getting your reset. There's no question there that you reset. Okay, you did your circularization burn, and the next thing is SIM BAY EXPERIMENTS DEPLOYMENT.

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WORDEN Before we talk about the SIM bay, I guess I should talk about the landmark tracking because that was the next thing that came up. After the circularization burn was the landing mark tracking from higher altitude. That went as planned, and everything worked out fine on it. I tracked the landmark with the telescope, and it was no problem. It was very easy to track the landmark. There was some concern about the shallowness of the particular crater that we were using, but it was pretty clearly visible when I checked it out.

I guess my only comment about the landmark tracking is that I would have felt much warmer about the landmark tracking if I had done it with the sextant, rather than with the telescope. The telescope presents a pretty large field of view, and you're trying to track a very small object down there. Apparently the numbers don't show that to be true — that there is a great deal of difference between the two. I think my own personal feelings would have been that I would have felt much better about it if I had done it with a sextant, because then I know I'm really on the target.

SCOTT You could have locked up on that target easy, I think.

WORDEN Easy with a sextant. In fact, I did it on subsequent revs when I came by in an attitude that would allow me to get the

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WORDEN (CONT'D) optics on it and track it all the way through. I guess the results of the landmark tracking were satisfactory for the ground to go ahead and update your descent.

SCOTT Okay, why don't you hold the SIM bay information until we get past the landing.

WORDEN The SIM bay stuff is sort of separate from the landing, and perhaps we should go all the way through that first.

SCOTT We probably should stick with our Flight Plan, rather than the debriefing guide, at this point. We did a DOI trim burn, and we might go back in history a little bit on that one. We expected a long time ago, I think during the data priority meetings, to see some orbital perturbations out of plane due to the mascons. We had them put in the Flight Plan an extra period of time to do a DOI trim burn, if it was required. Prior to descent day (after the DOI, just before going to bed) in order to plan the next morning, we asked what was the probability of doing the DOI trim burn, and they said very remote. The next morning, they called up and said we were going to have to do a DOI trim burn. Fortunately, we had the time allocated in the Flight Plan to do it.

IRWIN It seems to me that the perilune had degraded quite a bit during the night.

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SCOTT When we got up the next morning, they told us that PDI was going to be 33,000 plus or minus 9000 feet, which meant that we could be down to 24,000 feet at PDI. They were still thinking about a DOI. Well, that was a cue to me that we were definitely going to do a DOI trim burn, and I expected a 6-foot-per-second burn, which we prepared to do. That threw a little glitch into our thinking that morning, because we planned that morning to try and get everything done early. Because we had run through the suited exercise good once before, we got ahead of the game there, and we were able to get that burn done. I think it should be included in the Flight Plan if there's any question at all about it. If there's a 10-percent probability that you're going to have to do it, you should probably stick it in there. You really need the time to get in the LM and get it cranked up.

IRWIN The DOI trim turned out to be 3.1 feet, which we did with the RCS.

SCOTT Theoretically, that was to bring us up to 50,000 feet at PDI. I guess we'll have a couple of words to say about that when we get around to our altitude check. Okay, anything we missed along the way, Jim?

IRWIN We can start after undocking and just go through the time line, I guess.

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SCOTT We'll pick up with the LM from undocking to PDI. A general comment before we begin is that I thought the coordination of the two time lines in the two vehicles went very well. I think we always knew where the command module was, and the command module always knew where we were and in what sequence of events we were engaged at the time. I think it was a very comfortable time line, and we had plenty of time even to eat during that period in the LM and to take care of all the systems things on time, although we undocked a little late. The thing we ran was the DPS throttle check, and when we ran it through the first time, the DECA POWER circuit breaker was open. We have no explanation for that. I've checked it according to the circuit breaker list. I checked the row of circuit breakers, and then I counted the number open and compared it with the numbers we had there; it checked out. I don't know whether the circuit breaker opened during the check or if I missed it.

IRWIN It should have been closed before undocking.

SCOTT It should have been closed. The ground called us and said they didn't see anything and how about closing it, which we did. Then the DPS throttle check worked out fine. The window heaters, which we had turned on to take the condensation off the windows, seemed to work quite well. It got both windows cleaned up, and we never had to use them again. Concerning

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SCOTT
(CONT'D)

the approach to the landing site, I think we missed this one because we undocked late. We took movies of that because Al was right below us and we were just about over the landing site. So, we have a combination of undocking plus landing site pictures.

Rendezvous radar checkout went as prescribed. We mentioned the numbers already compared to the VHF. The alinement used the same two starts, Dabih and Alpheratz, again and used a regular P52 rather than P57. Again, Dabih was very difficult to see. The star angle difference was five zeros and the P52 was four zeros and a one. It was relatively easy to do. In my estimation, if we could convince ourselves that the P57 was as accurate as a P52, it would be an easier way to do an alinement because you don't have to maneuver the spacecraft; although, the P52 is not that difficult.

The torquing angles were small. The LPD calibration worked out well. I had to turn the lights to approximately the same intensity as in the simulator, and the star was about the same as in the simulator. We used Nunki and it fell right on 40 degrees.

IRWIN

The AGS activation worked out real smooth. I think we got all the entries in before we had LOS. The ground can probably

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IRWIN
(CONT'D)

confirm that. I think there was no doubt that we had all the entries in, and we had the K-factor before we came upon LOS. The timing worked out real well on that. Then we maneuvered to the AGS CAL attitude plenty early, so the rates were damped when we got around to the AGS CAL.

SCOTT

One of the things that happened in our planning was a little confusion as to attitudes. The AGS CAL attitude is rather arbitrary within certain limits, and we originally chose an attitude which would enable us to view the command module during the circularization burn. Unfortunately, we were using the wrong reset tapes at the Cape, which we discovered about a month before flight. When we got the correct reset tapes, we felt it was too late to make a change in attitudes at that time. Therefore, we didn't get to see the circ burn, which is only a "matter of interest" kind of thing, but it would be nice to watch. If you choose your AGS CAL attitude correctly, you can see the command module do that. The overriding factor is getting to the attitude early so that you have about 20 or 30 minutes to let the spacecraft damp. Then when you do the AGS CAL, you have very low rates, which we did.

The comm worked fine; configuration for LOS and AOS was fine.

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IRWIN The AGS CAL worked out real well. I read the values to the ground, and I don't think there was any problem at all on the calibration.

SCOTT The AGS looked good; DPS pressurization and checkout went well. The landing radar checkout went well. We came by and made an altitude check as we went over the landmark, over the landing site, and we got something like 8 or 9. Didn't you write that number down? We did two of them as we went by and we called it down to the ground. So, they have the data.

IRWIN I think it was 9 seconds.

SCOTT We read it down to the ground. I guess it's just a warm feeling. I'm not sure what you can do with the data anyway. We just ran it. Landing site observation worked out well.

IRWIN We might make a comment. Even after the 40-minute delay in undocking, we still picked up on the checklist and were right on the time line in very short order.

SCOTT Which indicates it's a comfortable time line.

IRWIN Yes.

SCOTT The maneuver to the landmark LPD altitude check was done in AGS, and that was when we found, during the simulations, that

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SCOTT (CONT'D) we had no checkout of the AGS part of the landing, which we felt would have been a good idea. And I checked it out in both attitude hold and pulse and it worked very well. Both control systems were very stable and positive.

IRWIN The next event was another alinement on the same two stars. We got four zeros and a one on the star angle difference, and the torquing angles were quite small again (0.010, 0.023, and 0.034), which gave us an indication that we had a good platform. The COAS calibration was approximately half a degree up. The star was about half a degree above the center of the COAS, and that looked pretty good. We ran the P63 ignition algorithm test, and the ground seemed satisfied with that.

SCOTT Pre-PDI ECS looked okay. We went to the switch list and came around the corner for PDI. Then we started getting a few surprises. The first thing we got was a PIPA bias update right after we came around the corner, wasn't it? Do you have those erasable loads in there?

IRWIN Yes, I wrote them down. Let me see if I can find them.

SCOTT Up to this point, we felt we had a pretty good platform, and soon after AOS on the PDI rev, the ground called up two erasable quantities for PIPA bias updates, which we loaded manually. I was a little surprised to see that. We went

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SCOTT through the procedures into the PDI as per the checklist, and
(CONT'D) everything seemed to be working just right.

IRWIN 1454 and 1452.

SCOTT Then, as I remember, at PDI minus 2 minutes, or something like that, we got another PIPA bias update, an erasable load, which we loaded.

IRWIN I had a surprise here on the loading 231. I had never done that in training, and apparently hadn't interpreted the time line properly. They called me on loading 231.

SCOTT Yes. I remember you even asked them about that.

IRWIN That was a surprise for me. I would have thought someone would have caught it during the training period.

SCOTT We got into PDI, the ignition part. Everything went as planned. We got a good ignition, good throttle-up, and were on our way to 2 minutes, and we got a call for a NOUN 69 or 169.

IRWIN What do you remember it as?

SCOTT Minus 2100.

IRWIN I wrote down minus 1600. That wasn't definitely a minus.

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SCOTT Yes. It was an uprange load. Well, we loaded it real time, as they called it, and the ground verified it was the right number. We entered it and proceeded on down to 3 minutes, at which time I yawed around to zero. Very shortly thereafter we got the altitude and velocity lights out on the landing radar. We had a good DELTA-H. The ground confirmed it was good and around 2500, as I remember. We saw a DELTA-H on the order of 2000 almost all the way down. But, it accepted the updates quite well, and I think we noted that there was a fair difference in the PGNS altitude and the nominal, wasn't there, on the way down? Like about 3000 feet?

IRWIN I think you're right.

SCOTT It almost agreed with the DELTA-H we were seeing on the DSKY. We got throttled down a couple of seconds early, as I remember. I evaluated manual control with the PGNS MODE CONTROL switch in ATTITUDE HOLD. All I did was check roll, pitch, and yaw to see if we had any red flags and went back to AUTO. Everything seemed to be in order. I called up a NOUN 68 to check the time at which P64 would occur, and it was 9:23, which was nominal. Just prior to P64, two events occurred which biased my estimation of where we were going to land. The ground called and told us we were going to be 3000 feet south. Right?

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WORDEN Yes, I recall that from the command module.

SCOTT I looked out of the window, and I could see Hadley Delta. We seemed to be floating across Hadley Delta and my impression at the time was that we were way long because I could see the mountain out of the window and we were still probably 10,000 to 11,000 feet high. I couldn't see the rille out the forward corner of the window, which you could on the simulator, out the left forward corner. So I had the feeling from the two calls that we were going to be long and south. When we pitched over, we got P64 right on time. As we pitched over and I looked out, there were very few shadows as far as craters go. I think the model gave us the impression that we could see many craters on the surface because of the shadow lines. I believe the overall problem was the enhancement of photography that was a little too high fidelity. In other words, I think they over-enhanced the photography and made themselves think the terrain had more topographic relief than it really did. When we pitched over, I couldn't convince myself that I saw Index Crater anywhere. I saw, as I remember, a couple of shadowed craters, but not nearly as many as we were accustomed to seeing. I measured my east-west displacement by my relative position to the rille, and I could see we were in fairly good shape, relative to the rille, but we were south. I could see the

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SCOTT
(CONT'D)

secondaries. I could see some shadowing in the areas in which the secondaries occurred. Knowing that we were 3000 feet south, which I'm sure will be discussed in the debriefing because that's not what they meant. I don't know whether you know that or not. They didn't mean 3000 feet south apparently. They meant azimuth. They meant that we were not coming in on 91 degrees. We were coming in at some other azimuth. But my interpretation was that our landing point had been moved. I'm sure we'll get that in the debriefing, but that was a confusing call. We were south, and I redesignated immediately four clicks to the right, and then very shortly thereafter, after you called me again on the LPD numbers, I redesignated two more right and three uprange.

I saw what I thought was Salyut Crater and the smaller crater to the north of Salyut, both of which are quite subdued on the model. I think, in fact, what I was seeing was Last Crater. Punch that. The Last Crater on the model is rather a sharp rim crater with shadows, and Salyut and the one north of Salyut are rather subdued. I think what I selected was a landing site relative to Last Crater rather than Salyut Crater, but it looked like Salyut and the one north of Salyut to me, and that's where I redesignated to. I'm not sure how many other redesignations I put in heading for the target as Jim called the numbers. I

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SCOTT
(CONT'D)

may have put in a couple more. I got busy, at that time, attempting to select a point for the actual landing. I guess our preflight philosophy had been that if we were on target, we would try to land exactly on target. If we had a dispersion, we would select some point within the 1-kilometer circle which looked like a good place to land and would land as soon as possible so as not to get behind on the propellant curve. Once I realized that we were not heading for the exact landing site, and that I didn't have a good location relative to Index Crater, I picked what I thought was a reasonably smooth area and headed directly for that. We got down to 400 feet, and we had planned to switch to P66. I gave one ROD click at that time. Jim called me on the P66, which verified the ROD was working, and I went on down to 200 feet and started rounding out at 150 feet.

I could see dust - just a slight bit of dust. At about 50 to 60 feet, the total view outside was obscured by dust. It was completely IFR. I came into the cockpit and flew with the instruments from there on down. I got the altitude rate and the altitude from Jim, and rounded out to 15 feet and 1 foot per second for the last portion. When Jim called a CONTACT LIGHT, I pushed the STOP button, which had been in the plan. Knowing that the extension on the engine bell was of some concern relative to ground contact, it had been my

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SCOTT
(CONT'D)

plan to shut the engine down as soon as possible after Jim had called the contact and to attempt to be at some very low descent rate, which we felt that we were at that time. The next event was the contact with the ground, which I guess was somewhat harder than the 1 foot per second.

One of the sensations in the LLTV which helped me was contact on the order of 1 foot per second, which feels rather hard with a tightly sprung system like you have on either of those two vehicles. We landed in a shallow depression on the rear pad. I think the rear foot pad was in a 5- by 15-foot shallow crater. Wouldn't you say that was about the order?

IRWIN

Fifteen to 25 feet in diameter.

SCOTT

It gave us a tilt of about 10 degrees left and 10 degrees up, which was subsequently no problem. There was a rumble when we landed. I think all the equipment on board rattled. It seemed as if I could hear it all when we landed, like you would shake the vehicle. Couldn't you hear that?

IRWIN

Yes, I agree.

SCOTT

Soon thereafter, we called Houston and informed them we were on the ground.

IRWIN

The propellant was about 6 percent.

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SCOTT About 6 percent, and that gets us on the ground. A couple of general comments on the techniques. I relied on Jim's call on the altitude and altitude rate and on the LPD. I felt I had a good handle on LPD and H and H-dot all the way down. I could concentrate out the window to try and select a point. I was very surprised that the general terrain was as smooth and flat as it was, with relatively few prominent features that could be seen. There were very few craters that had any shadows at all, and very little definition. The terrain was quite hummocky. There were smooth and subtle craters everywhere, which made subsequent motion and movement on the terrain there somewhat tricky. But at the altitudes looking down as we approached the landing, it was very difficult to pick out the depressions. I did know that I was landing past the crater which I thought was the one north of Salyut, which I believe now was probably Last Crater. I could see that I was going to land to the west of that, but as far as the other shallow depressions there and the one in which the rear pad finally rested, I couldn't see that they were really there. It looked like a relatively smooth surface.

IRWIN I put the altitude update into the AGS at 12,000 feet, and shortly thereafter (we were probably at 11,000 feet), I put in the altitude rate update. Immediately after that, I

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IRWIN
(CONT'D)

called 367. It looked like there was probably a difference of 1 foot per second between PGNS and AGS, so I think we had a good manual update of H-dot. When we got to P64, I did not look out the window at all. I just concentrated on the systems readouts so I could give Dave as much information as he needed. Everything else should be on the tape.

SCOTT

Okay. In going through the other notes here, we were probably fairly close to zero phase, and I didn't notice any particular effects on the zero phase as we approached the landing. I don't think that contributed to the wash out or the lack of seeing shadows. It was just a subtle terrain, and the rounded features prevented any shadows from showing. I don't think that was the zero-phase effect at all. The LPD was real good. I felt we were heading toward the point for which the numbers were being read. Manual control on the vehicle was excellent. I think it was more positive than the LLTV. I'll make one general comment. I felt very comfortable flying the vehicle manually, because of the LLTV training, and there was no question in my mind that I could put it down where I wanted to. We landed exactly where I was headed. In spite of the fact that the rear pad was in a crater, that's just where I wanted to land. I think our horizontal velocities were zero lateral and I had about 1 foot per second forward to keep from backing

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(CONT'D)

into anything. That's exactly what I wanted. There was no tendency to overshoot in attitude or overshoot in the selection of the landing site. I think all of this is because of the time that I had to work with the LLTV. I guess I can't say enough about that training. That puts you in a situation in which you appreciate propellant margins and controllability. I think the LLTV is an excellent simulation of the vehicle. I think if you had to move from one point to another, you could do it quite well. I would recommend maintaining an altitude of at least 150 feet so you don't get into the dust problem. I think dust is going to be variable with landing sites.

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10.0 LUNAR SURFACE

10.1 POSTLANDING AND SEVA

SCOTT Everything worked as advertised. We got the venting going and and I think it vented somewhat slower than the simulator. As I remember, we had time to do a few other things before we got down to the minimum fuel and oxidizer pressure.

IRWIN There was a little confusion on the P57, using two NOUN 88 stars. That held us up a little bit. It was just because we hadn't done it recently.

SCOTT Yes, I think the problem was that we never got a confirmation from the ground that the erasable load in the P57 was the right thing to do. We did it, and it seemed to finally work. I guess not having worked with NOUN 88s for a long time, it took us a little while to get through it. I think we ended up fairly close to the time line in spite of that.

IRWIN I don't have any other comments coming into the standup EVA day.

SCOTT Let me comment that the stars, even though new and different, we had Schedar, which was in Cassiopeia and we had Alhena which was in Orion and even though they were not mass stars, they were easily recognizable. The numbers that were called up, cursor and spiral, were very close. There was no trouble identifying

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SCOTT (CONT'D) the stars and ensuring that they were, in fact, the correct stars. The alinement was straightforward once we got the 188 procedures squared away. We got a .01 on the first star angle difference and five zeros on the second star angle difference. I think we finally ended up complete with the alinements at about the right time, within the checklist. The new procedures developed by MIT to perform P57s are very good and save quite a bit of time. We had an extra pad in there, based on the old techniques of having to go cursor and then spiral. Now that you can go straight through, it saves quite a bit of time, and it's a valuable improvement in the program. We did not do the 10-minute gravity exercised with the platform. It seem to me that they called us right away and said to go ahead to P6 and we wouldn't have to do that. I don't know why they canceled that; maybe they had enough data by that time anyway.

IRWIN We were running a little bit behind time because of the delay on the P57s.

SCOTT I wasn't watching the clock at that time. Did we end up behind on the time?

IRWIN We were a little behind. They wanted to get us bedded down so we could get out on time the next morning.

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SCOTT Okay, we went through the switch list, did the equipment prep for the SEVA. We didn't discuss our position more than a comment on what it looked like on the way down. We were saving, I guess, trying utilize the time so we could discuss the position of the landing site through the top hatch.

I thought the equipment prep for the SEVA was very straightforward. We went per the checklist on the SEVA prep, got the hatch open, pulled the drogue out (which was very similar to the one-sixth-g airplane exercises we had), and when I stood up in the top hatch, I found that because of the one-sixth gravity, I could support myself on my elbows without having to stand on anything, and get fairly well out of the hatch. I guess the first thing we used was the Sun compass to try to get a relative bearing on three sites. We used Benefield 305 and Mount Hadley to get bearings. And then you passed up the camera for the pans, and then the 500, and I took probably about 20 pictures with the 500 and described the general area. My impression, looking out, was that we had good surface on which to travel with the Rover. I could see the Northern Complex almost completely, and I could see the base of the Front, and all the way up the side of Hadley Delta. There were no boulders anywhere which gave us some confidence that we could make pretty good time with the Rover, if the Rover produced for us as far as

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SCOTT
(CONT'D)

performance. There weren't any obstructions other than the many small and subtle craters. The general surface was rolling, smooth, hummocky and very much like 14. Although there were not a lot of boulders, there were a lot of small craters, which we could see were going to require some navigation. We could see that the trafficability was going to be good. I could look out to the west and see a spot that was fairly level for the ALSEP, and confirm that we did have a place we could put the ALSEP. It was not apparent that there was any place in the immediate vicinity of the IM to place the ALSEP. I couldn't tell exactly why we had the tilt on the IM. It wasn't clear that we had put the rear foot pad in the crater, which we subsequently found. I couldn't tell that from the top hatch, although I could see there were a number of shallow depressions and smaller craters in the area. But, it did look like a good place to put the ALSEP within a reasonable walking distance. I couldn't see the rille, or define the rille, but I could see the far side, Hill 305 and Bennett Hill, which looked a great deal closer than I had expected, as did the Northern Complex. Geologically, we could see there were few fragments in the area and no boulders. One apparent observation was the secondaries which had gone up the side of Hadley Delta. I think immediately it was obvious that the secondary cluster had swept up on top of the Front rather than the Front coming down on the

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SCOTT (CONT'D) secondaries, which gives us an age relationship. About Hadley itself, the Swann Range, the Big Rock Mountain, and all the features to the east were still in shadow so I couldn't see anything there that I could define specifically that we had geologically. You could see the Northern Complex, however. I could see the inner walls of Pluton and they had large fragments, probably on the order of a couple of meters, on the inner walls. They probably represented 3 or 4 percent of the debris that I could see on the wall, although the inner walls seemed to be all relatively smooth, free of talus. I saw nothing on the outer wall of Pluton. It looked pretty smooth and similar to the rest of the local surface area. I could also see Icarus and Chain; a very good vantage point primarily because we landed on a topographic high. This proved to be helpful; subsequently, when we were great distances from the IM, many times we could locate it.

IRWIN We did take color and also black and white.

SCOTT We came back in after the SEVA, and I might say in conclusion that the SEVA was a very useful thing. I gave us a lot of confidence that we could get to the Front with the Rover and also to the rille and the Northern Complex. I felt we had all three of them pretty well in hand for traveling, in spite of the fact that it was obvious that we had not landed precisely at the

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SCOTT (CONT'D) preplanned point. At this time, I wasn't sure where we were located. Although I could see prominent features, I was relying on the Sun compass to give us the data for triangulation to spot our point because there was nothing in the immediate vicinity which was recognizable. I think this was general throughout the rest of the EVAs. The terrain was considerably different than we had been led to believe, because of the lack of high-resolution photography. I think, in retrospect, the enhancement of the photography provided more detail than was actually there and that fooled us a little bit.

IRWIN How about comfort while you were there, were you particularly warm without the LCG on?

SCOTT No, I was very comfortable. As a matter of fact, I thought the cooling was fine, and there was no problem at all wearing the CWG. As a matter of fact, I thought it was more comfortable wearing the CWG. How did you feel?

IRWIN Yes, I was plenty comfortable. I just thought maybe you would be a little bit warmer, being up in the Sun. There wasn't any sunlight at all coming in on the front panel. We were concerned about that beforehand, but there wasn't any coming in.

SCOTT In summary, the SEVA was very easy, the procedures were simple, and there were no problems encountered.

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SCOTT (CONT'D) The next thing is the eat and rest period, and the suit donning and doffing. As we came back in to repress the cabin, no problems. We took our suits off, and, there again, no problems. I think training had prepared us for the doffing of the suits, and I can't remember having any trouble at getting out of the suits. Can you?

IRWIN No, we configured them for drying; although they probably did not need drying, we decided to go ahead and do it.

SCOTT Why don't we make a general comment for all the suit doffing while we're here since I don't think we remember having any problems getting out of the suits? I think that at the conclusion of each EVA, we configured the suits for drying. We let them go for about an hour, and more in some cases, and unplugged them and configured the ECS for sleep, which was no problem.

IRWIN We ate and while we were eating, we did the PISS water charge and topped it off. I frankly don't remember what the orientation of my PISS was when we did the water recharge, but I guess it was off-vertical somewhat.

SCOTT Maybe a little bit, but at that time, the cabin wasn't too crowded, nor was it dirty. I think there was another — maybe an advantage for sleeping. We got to sleep the first night in a clean cabin.

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IRWIN I thought we had my PLSS on the midstep.

SCOTT I think we did when we charged it. We didn't have to do the oxygen charge. It was probably level. I guess we might relate to the problem here, since we're on it.

IRWIN There was a subsequent problem with the water cooling in my suit, my PLSS.

SCOTT But I think that, at that time, we didn't have it vertical when we charged it. Okay, on down to the sleep period, or the eat period. I guess we ate the meal that was provided. And I think that I'll mention, in general, that I don't think there's enough food on the LM, and I think we ate everything that was there. I think that, for the activity we have on the surface, that you need more food in the LM.

IRWIN Particularly those food sticks would really come in handy.

SCOTT I'd say we could take at least twice as many of those easily, because you can eat those during the preps and posts.

IRWIN The first night's sleep on the LM was the best night's sleep I had on the total flight.

SCOTT Yes, I slept quite well too. I was surprised that the hammock was as comfortable as it was. I think in the one-sixth g

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SCOTT environment that those hammocks work just fine, don't you?
(CONT'D)

And the suit positions were fine. I think the whole layout of the cabin was quite adequate. We have no comments or recommendations on a change on that. It worked out just fine.

In looking over the events on the surface, I think we'll go to the systems within the spacecraft in sequence and then come back and go through the events which occurred after the hatch was open. So we'll really have two categories of surface activities, one of which will be in the cabin — we'll discuss that now from end to end — the other of which will be on the surface, which we'll discuss after the cabin events. After the good night's sleep, we awakened the next morning.

IRWIN They awakened us early because of the O₂ leak to the urine transfer device. And I think part of the problem on that was that the top seal, the double seal on it, the cork plunger there, was not completely seated after we used it the night before.

SCOTT Had we ever been briefed on that thing?

IRWIN No. Well, we had told John that we planned on connecting it and leaving it connected. Nothing was ever said against that.

SCOTT Yes, but I don't think there was ever any discussion. It had the two seals on the plug and it had one valve which, I guess,

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SCOTT we felt, prior to the flight, would be adequate for leakage
(CONT'D) prevention.

IRWIN And it might have been, had we had the plug fully seated. Anyway, the plug wasn't fully seated, and we had leaked some oxygen. So that was the first call from the ground to check it. Well, they didn't know where leak was, but it was pinned down quite quickly to that being the cause. So we took the urine transfer device off the hose and capped the end of that line, and that stopped the leak.

SCOTT And I think there is a point you're inferring there. I think we'd have been better off had the ground called us once they recognized that there was some leak, even though it was in the middle of the night. I think we would have slept better on subsequent night knowing that any small thing would be corrected immediately before it got us too far down. I guess our recommendation there would be to call the crew if the ground sees any problem which might develop into significance later on.

10.2 EVA PREP AND POST

We got up in the morning and had breakfast and proceeded with the EVA prep for EVA-1. That seemed to go, as I remember, fairly well. I don't know what the timing was on that. We might tell you here that the mission timer was turned off for

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SCOTT
(CONT'D) power savings, and we were going on Houston's time on our watches. There really weren't too many references within the surface checklist to the Houston time, so we were not really conscious of where we were relative to the g.e.t. or relative to the timing and relied on Houston to keep us abreast of the time. We just proceeded through the checklist as expeditiously as we could. I do remember we asked them during the EVA prep when they expected us to depress. That came out on time, so we were pretty well going with the time line as planned.

IRWIN I think I made the comment that I was glad that they had awakened us about an hour early, because we went into our first EVA very leisurely. There was plenty of time; there wasn't any rush at all. In fact, I think I made the comment that I just as soon wake up an hour early for the subsequent EVAs to give us a little more time to think about things and get organized.

SCOTT That's a good point, because here again, we've got a plan which says eat and rest, and we don't have all the transition things in there. They are in the checklist, but I'm not sure there is adequate time. And a rest period, I guess, we might define as not necessarily closing and opening your eyes, but as a period during which you've had no scheduled activities, wouldn't you say? If you had some little cabin things you want to take care of during your rest period, like the biosensor change or some

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SCOTT housekeeping that has to be done, I think that can be easily
(CONT'D) included in the rest period.

Let me interject here that we're reorganizing the plan a little bit and discussing the LM activities in the cabin as one category. And then, within the surface activities, we'll subdivide that into two categories, one of which will be all the equipment that was utilized on the surface, and the other of which will be the science and the geology part. I think we can present a more organized approach in doing it that way.

So, back to the prep for EVA-1. I guess I might add to Jim's comment on having an extra hour in the morning, to go through it leisurely really helps. I think we saw this later on in the flight, too. You could be more sure of doing things right if you proceed to it leisurely, which I think we planned within the nominal training anyway. We had plenty of time during our training months to do the EVA preps leisurely.

IRWIN We would have had plenty of time on the subsequent EVAs if we hadn't had those problems.

SCOTT Just accept the fact that, if you have problems, you're going to fall behind. The checks on the EVA prep went very well. The comm checks all sounded good. And we got down to cabin depress, and I guess our only problem was - -

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IRWIN I might make one note there. When I unstowed my PLSS, I noticed that there was a large hunk chewed out of the antenna. About half of the width of the antenna was gone.

SCOTT And about an inch long.

IRWIN Yes, like somebody had taken a pair of snippers and snipped a piece out of it, right at the base, about a couple of inches from the base of the connection. We put a piece of tape around that at that weak point, and on EVA-1, we pressed ahead.

SCOTT They should have the antenna because we brought it back on the OPS that was in the CM. It looked like somebody really missed something in the PIA of the OPS. When Jim unstowed it, he found it right away. It was a pretty gross oversight.

The depress went all right, and then we started having some problems hanging up in the cabin. I think that they were magnified by the one-sixth g environment because we didn't compress the suits as much in one g, and I think we both were riding a little bit higher, and a little lighter. Turnarounds within the cabin were very difficult, and my hangup problems were on the mounting lever or shaft that holds the PLSS and recharge station, in the handle of that. Jim finally figured that I was hanging up on that handle, and we put some tape on it, across the handle on subsequent EVAs, which did help. It was also hanging up on

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SCOTT the corner of the Flight Data File, which is a sharp corner, and
(CONT'D) also on the DSEA guard, the wire cover. It's very crowded in there, and it takes a lot of time in moving about the cabin to prevent hangups, and I think we lost, overall, quite a bit of time. I wouldn't be surprised if we didn't lose a total of a half an hour. Do you remember when you were hanging up?

IRWIN One thing was the water hose. The other was — you know, after you disconnected your umbilicals, they were not stowed as far aft as they probably should have been.

SCOTT We got that corrected on the second one.

IRWIN Yes, once we pushed them way back in the aft, it was all right. And another problem was when we stowed the bracket that holds the PLSS to the floor, we didn't get that pin fully secured, and that bracket did not go down flush with the floor, so the hatch would not open fully. This caused a subsequent problem for me, getting out and getting back in. Another problem that I noticed was the strap length. It's measured in one g, and I think that's a mistake. Because my controls were just too high at one-sixth g. The PLSS was just riding too high. I had a difficult time getting to the controls.

SCOTT I thought the strap length was measured in the rig that supported the PLSS at one-sixth the weight.

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IRWIN It was on the rig, but something's different.

SCOTT You felt your controls were a lot higher. Mine felt fine. I didn't have any trouble reaching the controls, other than when my fingers got sore. I noticed your PLSS seemed to be sitting in an angle, too, where your controls were further behind, you tilted. It looked like you had more trouble. Do you remember any of the other things you were hanging up on.

IRWIN I can't think of any other things I was hanging up on.

SCOTT Well, then we get down to the depress and the hatch opening. The hatch was very difficult to open partially. I guess we expected that because of the pressure on it, from previous flights. Once we got it open, it could be held without any trouble.

Got the GO for the egress, and I didn't have any particular trouble getting out. I think that's because you were guiding me as I went out. I remember you gave me a couple of "move rights" or "move lefts," something like that, and I didn't have any trouble getting out. Maybe you ought to talk about your problems getting out. I didn't realize the hatch was only partially open.

IRWIN I guess we lacked about 40 degrees on hatch motion. I had to go a little more right than I normally would. I think I was hanging

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IRWIN up on the right side of the hatch. I had to ask you for guidance
(CONT'D) when I initially came through the hatch.

SCOTT Your whole back was hanging up on the ACA mount because you were too far to the right. With the hatch only partly open, you got yourself too far over to the right. I remember when you went back in and I was going to see what was hanging up, and you were hanging up underneath the ACA mount.

IRWIN Once the hatch was configured so it would fully open, it wasn't any problem getting in or out.

SCOTT We'll step ahead to getting back in then. I guess you had the same problem getting in because of the same reasons. I think once we got everything in and you discovered that the hatch wasn't fully opened, why that made it a lot easier from then on. I guess I didn't have any problems getting back in, because again you were able to guide me as I came in through the door.

The cabin repress: I guess when we got back in, I noticed that things seemed to be much more crowded than I had remembered several hours before. I guess that's when we had the freedom of mobility outside. And I had a tough time getting to my water to turn it off, and I think you did too.

IRWIN In fact, I think I asked you to get mine. It could have been a function of our hands being so doggone tired.

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SCOTT Yes, I think it probably was. But still it was very crowded and very difficult to move around. Once we got the hatch closed and repressed, why we sort of took a break right there, which I think wasn't really in the time line. But it was a good place to take a piece of our rest period. I remember we got the helmets off and stood there and talked about it for a while before we went through the rest of the function.

IRWIN I'm trying to think of when we noticed the break in the bacteria filter.

SCOTT I think it was right after we got our helmets and our gloves off. I think you looked down and saw it. The water was in and out of there, the hose right at the connection where the bacteria filter joins the water hose. The bacteria filter has some plastic attachments to it. There were two little knicks about, probably a quarter of an inch long and about a quarter of an inch wide out of the side of the plastic connector. The water was flowing freely and we had no idea at that time how much water had come out, nor how long it had been flowing. There was no way to really tell. We looked at the floor, and there was a little bit of water on the floor, not much. There was no evidence of a great leakage rate, although the spacecraft was tilted. We found out subsequently it had leaked, I guess, about 25 pounds back in the aft portion of the cabin. Then we

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SCOTT disconnected the filter; that stopped the leak.
(CONT'D)

The first order of business after we got repressed was to go through the checklist and do the EVA post and try and come up with a plan on how to handle all the dirt in the cabin. We were pretty dirty. We had planned prior to the flight to take the jettison bags and step into them with the suits to keep the lower portion of the suit isolated from the rest of the cabin. Our legs from about thigh down were just about completely covered with dirt. I guess the dust brush worked fairly well. I got the most part of it, but we were still pretty dirty.

The O₂ recharge. The first thing we did was the O₂ recharge. That went as planned. We got to everything all right; even though the O₂ line was a little short at that stage, we could reach it. Then we docked the PLSSs and took off our PGAs. Then we started hunting, as I recall.

IRWIN I had the impression we had more time there. We were moving pretty slowly. We could have easily got some of that recharge while we were eating, which we did later.

SCOTT We could have combined some things as we did do later. We were going sort of slow, feeling our way around the cabin, trying to get settled down to some sort of system to control the dirt and stay organized. I think the jettison bags over the legs worked

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SCOTT (CONT'D) fairly well. I think we kept the majority of the dirt out of the cabin and kept it in the bag. We just cinched the bags up around our legs. It was no problem getting in and out of our suits with the bags on them. We took another jettison bag and stuck it up on the midstep, and I stood on that to keep my CWG clean. You stood on one of the OPSs to keep off the floor, which was pretty dirty. Now, we get down to the water charge. On my first, the water charge went as advertised. At this point, when we charged yours, we probably had to tilt it.

IRWIN We layed the PLSS on the suits, as I recall.

SCOTT What we were trying to do, to save a little time there, was to charge water and complete the O₂ recharge at the same time. All the connections to be made to the PLSS at about the same time would save a series operation. The high-pressure O₂ line wasn't long enough to reach the PLSS unless you tilted the PLSS and we found out later that the ground suspected some substandard water charge because of the tilted PLSS. We had to lean the PLSS over in order to get all the hoses connected to it simultaneously. I'm not sure that that was really a problem, even though we corrected it by recharging vertically later on. The stowage went as planned. We didn't have a lot to stow on the first EVA. We put bag 4 back in the box which contained the 500 millimeter on the way down, dried the suits, configured the ECS for sleep,

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SCOTT and proceeded to sleep. Can you remember anything else on
(CONT'D) that?

IRWIN No. I thought most of that was fairly nominal.

SCOTT Getting out of the suit again was no problem. I think the
procedures established were quite adequate.

IRWIN The hammocks are adjustable to a certain degree, and we were
pitched up which meant that my hammock would be tilted back. I
didn't notice any problem at all. I slept very comfortably and
I think Dave did, too.

SCOTT I was afraid I would be feeling like I was sleeping heads down
with that pitch angling there, but I didn't at all. The suits
were a lot fluffier than they are in one g. They compress and
they were right up to the bottom of my hammock, but that didn't
bother me either. As a matter of fact, it was almost like a
nice little bed up there. I guess we had some concern that the
hammocks were not going to provide the reasonable sleeping posi-
tion; but after we had done it a few times, I think it worked
all right. I think at any choke angle you can adjust those
things so it will give you a good position.

IRWIN One improvement I would suggest is extending the bottom of my
hammock up to the connectors. There is a gap of about 2 feet,
and my legs would dangle down at night.

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SCOTT Oh, really?

IRWIN It wasn't any problem. I found that most of the night my legs were up and kind of resting on top of the comm panel.

SCOTT I felt like I might put my feet on the control switches. I took a piece of the webbing we had on board, cut a hole in the bottom of the hammock, and tied the bottom up to the AOT guards so my feet wouldn't slide down onto the switches. I think you can improve the hammock by providing those two little items. You can make them wider, too. They're not quite wide enough to put your shoulders on them. Other than that, there is no problem.

The night went all right; but at some point along the way in one of the nights, we got a call for Endeavour. Did you hear that one?

IRWIN No, I didn't hear that one.

SCOTT You didn't hear that one. Yes, the Endeavour called one night, which made me think a while about where I was. Was I on the Endeavour or the Falcon or where? I think it might behoove CAP COMM to be sure they punch up their right key when they are talking to the different spacecraft, because that can make you come out of the hammock pretty fast. When we woke up the next morning, I was surprised how clean the spacecraft was. I think most of the dust had been removed. That's right. It surely had.

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IRWIN That night, it was fairly clean, you know, when we went to sleep. I don't know how all the dust got out of there.

SCOTT Yes, the ECS does a pretty good job of cleaning the place out. The smell was gone. When you took the helmet off, you could smell the lunar dirt. It smelled like -- the nearest analogy I can think of is gunpowder. But that had all cleaned out. By the time we got up the next morning things were in pretty good shape.

The first thing that occurred, I guess, the next morning was a call from the ground about how much water we thought we had lost and to check the aft behind the engine cover. We did, and sure enough, there was a great big puddle back there. The ground suggested using a food bag and LiOH canister to get it all up, and they wanted all the water cleaned up before we depressed. That was probably a pretty good idea because immersed in a puddle of water were a couple of glycol lines and some wires.

Thereupon, we entered into another mopping operation. We took one of the large meal container bags and cut it out like a scoop, and Jim passed me the canister cans. I scooped up the water, and then we took towels and dried up the rest of it. I think we got it completely dry.

We got two full LiOH cans and locked them with their locks to make sure the tops wouldn't come out. Then we got another half

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SCOTT (CONT'D) can, at least, in the helmet bag which we had intended to throw out; but we subsequently found it was dripping, too, so we took the ground's suggestion and dumped it into the urine container. We had plenty of storage space after handling extra water and all the urine, too. So I would say it worked pretty well.

IRWIN The temperature in the cabin was very comfortable. I slept in my CWG in the sleeping bag and did not use the coveralls.

SCOTT I slept in my coveralls without a sleeping bag; so I guess we each had two layers on, and it was very comfortable. We also used your earplugs, so noise was no problem.

IRWIN The earplugs worked very well.

SCOTT There was some light leakage which you commented on. The stitching around the window covers provided light leakage around the main left- and right-hand windows, but it wasn't any problem. I think the final ECS configuration they came up with as a result of the chamber run was a good one. That, plus the ear plugs kept things pretty quiet. The only noise you could hear was the constant tone of the glycol console.

I guess that gets us up to breakfast on the prep for EVA 2. We were starting to run behind because of our mopping operation; however, the EVA 2 prep, went nominally. I can't think of anything off nominal up to the comm check. Can you?

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IRWIN No. It seems at this point, that we did a water recharge on my PLSS.

SCOTT Yes, that's right.

IRWIN At this point.

SCOTT Yes, because of the expected tilt problem.

IRWIN Yes, and that probably took us an additional 15 minutes to recharge the water on my PLSS.

SCOTT I guess the suits went on without a hitch, and the banks worked all right. We kept things fairly clean. We went down through the checklist in a nominal fashion until the comm checks at which time we noticed that when Jim went to his portion of the comm check, we could not hear him. Isn't that right? Or you could not hear us.

IRWIN I could hear. I wasn't transmitting. It was zero.

SCOTT We took a look at the antenna again and found that it had broken off at the root right down inside the OPS; so we took a couple inches off the top, spliced it, and taped it down. That seemed to solve the problem. The ground then informed us that we would not have to have Jim's antenna up anyway because his comm was so good, so we left it down. I would say that's probably

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SCOTT a pretty good nominal procedure to leave that antenna down if
(CONT'D) you don't really need it up.

IRWIN I don't know why they subsequently asked for your antenna to be up because it looked like we had great comm with it down.

SCOTT Yes, that's right. I think that would be one for the systems people to think about because it would surely prevent any possibility of knocking that antenna off somewhere along the way hooking it on the high-gain antenna on the LCRU or the LM, or something. It also saves time.

Cabin depress. I guess we got the hatch open all the way, and I did not have any trouble getting out. Did you then, with the hatch open?

IRWIN No.

SCOTT I guess we'll step ahead to getting back in on EVA-2. We had no problem getting in and closing the hatch. We again had trouble getting hold of the water valves. That is probably because both of our hands were hurting at the end of the EVA. It's just hard to feel with them. Anyway, I think we got them locked, but wasn't this the time that yours really didn't get turned off, and didn't we get a little bit of water in the cabin?

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IRWIN I think it happened on both EVAs. On the first one, you turned it off, and I must have bumped it on something and turned it back on.

SCOTT Well, maybe I didn't get it off.

IRWIN No. It happened both times, I think, because you turned it off both times, and then after we repressured, it was on again; so I must have been bumping it on something.

SCOTT You felt the water in your suit, didn't you.

IRWIN Yes.

SCOTT That was a clue.

IRWIN I felt it and heard it gurgling and running down my right leg, so there was good reason to dry the suits.

SCOTT PLSS water, huh?

IRWIN Yes, it was really water.

SCOTT That's true. It would be a good idea to dry those suits. It wasn't any problem, but once you felt the water and we got the water turned off for sure, then it stopped running. I don't think we ever accumulated enough water in the cabin to even see; it was mostly in your suit.

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IRWIN I don't know. A little bit of that water on the floor there might have reduced the amount of dust on the floor. The floor was always kind of moist.

SCOTT Yes, that's true. I might comment that lunar dust is very soluble in water. It seems to wash off very easily. I would say if you ever have a connector problem that was really stiff, you could take the water gun and spray it in and loosen it up.

IRWIN We did not loosen the suit connections for EVA-2 but we did for EVA-3.

SCOTT It seemed like they were still working pretty well. The connectors got covered with dust — one of mine. One of the primary problems was the LEC. On EVA-1, when I passed you the rock box on the LEC, I just got covered with dirt all down the front. The result was pretty dirty connectors. We tried to brush them off and clean them off. We found that the booties which had been placed over the PLSS connectors were good protection from dirt. A recommendation would be to put booties over all the connectors or some sort of protective device. In the old days, they had a bib to keep them clean — or for double protection, I guess. Something like that would surely prevent problems later on and would save time cleaning the connectors. They sure get dirty, and I am just not sure there is any way to prevent

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SCOTT (CONT'D) them from getting dirty. If you are going to go out there and do the job, you are going to get dirty. If you try to keep everything clean, you are just not going to be able to do the job on time. I think those little booties are a pretty good idea. They were no problem on the donning and doffing. EVA-post went all right. Suit doffing went all right. We made sure the PLSS was vertical when we recharged the water.

IRWIN They did call up and ask us to go to 10 minutes. It really isn't any problem to combine the PLSS recharging with your eating. As a matter of fact, that would be a good procedure — to get everything set up to do your recharging the PLSS and then let the PLSS recharge while you are eating. It would save some time.

SCOTT It seems to me that the last night's sleep was about the same as the others. We talked over getting up early to make sure we didn't fall behind. We were going to try to awaken 45 minutes or so early, and that is exactly when the ground called us the next morning. It was just about the time we thought we ought to get up.

IRWIN It was just about the time we thought we ought to get up.

SCOTT They told us then Wednesday to get 7 hours for sure; and looking at the time line, we figured we needed it.

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IRWIN I guess they were concerned about whether we did not get a good night's sleep that night.

SCOTT Yes.

Didn't you feel like you had?

IRWIN I thought I slept just as good that night as I had the night before.

SCOTT I would question how they know you got a good night's sleep; except other than asking. The heart rate is a great idea, except do they ever measure your heart rate while you're sleeping at home?

IRWIN No, but I guess they want to do that.

SCOTT I think they ought to. I don't see how they can possibly correlate it, otherwise.

Well, I got a good night's sleep that night, it felt like to me. When I got up the next morning, I remember asking how you slept. You said you slept fine. So, I felt like we were both well rested for that day.

IRWIN On this last morning we didn't put water bags or food sticks in the suit, because we knew it was going to be a relatively short

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IRWIN EVA. On previous preps we did put the food sticks and the water
(CONT'D) bags in the suit.

SCOTT The last EVA would be short enough that we wouldn't need them. We didn't want to take the time to fill the water bags and put them in, because that was taking time away from the EVA. The prep went good, the comm went good, and I guess we got into the depress. I don't remember exactly what time it was but we were letting Houston keep track of the time. I think it would be good to have some sort of procedure for what time we could expect the various events to be occurring. We did the checklist on Houston time so we could have something to refer to. Depress and out the hatch without any problem.

IRWIN I do not think we ever hit any circuit breakers during the operation.

SCOTT Yes, that's right. I do not think we ever did. Everytime we checked them they were configured right. We did lubricate all the wrist rings, connectors, and helmet rings on this one, which was easy. I think that little dab of lubrication material works just fine.

IRWIN It was easy and I think it paid off because it was very easy to make the connections.

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SCOTT We never had a problem with the zipper at all. Both zippers worked very good throughout the flight. I don't remember ever having your zipper hang up. I thought the lock box worked fine. I guess we can't think of any improvements on that.

The post-EVA went well. We configured as per checklist, prepared for the equipment jettison and jettisoned all the equipment that was planned. The procedures worked well. We got into the launch pad — Can you think of anything in that period that didn't work as planned?

IRWIN I guess we could have saved some mental activity there if we had let the ground tell us where to put the bags. They came up with a plan and I did not know that they were going to do that.

SCOTT That is right. The preflight plan was to take the checklist we had on board, and the limitations on the weights and stow according to that checklist. After we got all stowed, the ground called up with a plan and said here is where we think you ought to stow everything. I guess we just read them our stowage from the checklist, and they accepted that.

IRWIN It turned out to be very close to what they had, but it would have saved some time.

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SCOTT It sure would have. Once we got back in after EVA-3, they could have said stow this here, and here, and there. We would not have had to figure it out. That would have saved some time. But I thought, in general, the post EVA-3 time line went right down the money all the way. I think we were within probably 5 or 10 minutes of every event.

If you're not careful with the vertical straps going up to the cabin fitting, you can put extra stress on that PLSS mounting; also, the interface of the straps could take off the thermal cover of the PLSS.

IRWIN The straps on the Commander's side occasionally bear down on the Y-adapter and also the PLSS hard line. We should look at it closer during the C²F². We should look strongly at some other way of securing the PLSS - -

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10.3 EVA-1 EQUIPMENT

SCOTT Okay, we'll take this egress on EVA-1 to the end of EVA-3 relative to all the hardware on the surface. Okay, moving through the hatch and down the ladder was nominal. The MESA came out and went straight to the surface as we expected, there was no preplan adjustment hike and it went right on down to the ground. Jett bag and LEC went down all right. I descended to the surface and hopped out and found that the one sixth-g environment was pretty much as everybody else had said. There was no problem going down the ladder. The front footpad was only very lightly on the ground. There was only very light contact.

IRWIN I question whether it was even in contact with the ground because it was so free to swivel.

SCOTT Well, it was when I got out because it made an impression on the ground.

IRWIN It might have made an impression and then it might have rocked back.

SCOTT The pad was on the ground when I got down the first time. It was pretty solid when I stepped down because I stood on the footpad before I stood on the ground. The ETB was transferred down all right. The MESA height was easy to adjust.

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(CONT'D)

I think it weighed some 400 pounds and there was some question before we went as to whether it would take two of us to adjust it to a reasonable level, but I had no trouble at all using the black adjustment strap and locking it in place. When I opened the blankets, I found that they had been taped together in addition to being Velcroed and that took a fair amount of time to get them open. I suggest that if we're going to tape them, then we ought to train with the tape on them. I thought the Velcro was going to be adequate, but I guess not. Jim came down and I unstowed his antenna. The TV tripod was fine and the TV camera was fine. We put the camera in the shade which nobody had mentioned prior to flight, since it was obviously looking up-Sun and the picture would be a lot better in the shade, which was somewhat closer than the preplanned location of the TV camera. Then we got ready to deploy the Rover. I guess the first thing we noticed when checking the Rover was that the walking hinges were both loose, or disconnected. Resetting them, I found that they'd lock into position okay but it was obvious that they had been too loose, or the design needs to be improved to hold them in position. I could see why any vibration at all would shake them out of their seated positions and cause them to fall open as we found them. They reset okay, and the Rover appeared to be parallel to its mounts and the outrigger cables were taut.

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SCOTT
(CONT'D)

I deployed both tapes and when everything was ready to go, I gave Jim a call and he was ready to deploy it. Did you see anything off nominal when you pulled the handle to deploy?

IRWIN

Okay, going back a little. When I started coming out of the hatch, I hung up a little bit because the hatch wasn't fully open and Dave had to guide me out. I got down to the surface and immediately felt at home in the one-sixth-g environment because of all the good training we had on the centrifuge POGO. I immediately moved out to take the contingency sample at about the 11 o'clock position to the LM, at about 30 feet. I collected that, moved back to the LM, and immediately configured the 16-millimeter camera, which is not according to checklist, but we had talked it over and decided that we wanted to get some 16-millimeter pictures of the Rover deployment. I had no trouble making the connection. I put the correct mag on the sequence camera and mounted it on the LCRU. And then I positioned myself on the ladder to release the Rover.

SCOTT

Did you notice anything when you pulled the lanyard? It seemed normal. The Rover came out in its deployment just like we'd seen in training. I might add that it was a good thing that we'd gone through all the training we had on the deployment of the Rover because it was easy to recognize the walking hinges being open, and had we not recognized that, we probably

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SCOTT would have had a serious problem.
(CONT'D)

Anyway, the Rover came down very well with a manual deployment. And everything was nominal until we got it on the ground and attempted to disconnect the saddle and the telescoping rods from the front. I don't know why they hung up. Both pins were pulled. It finally took some pulling, picking up the Rover and pulling by both of us to get it disconnected. I didn't see why it was hanging up other than that two studs in the bottom saddle that sink into the frame on the chassis of the Rover seemed to be hanging up. Other than that I couldn't tell, could you Jim?

IRWIN No, I'm trying to recall. We were pulling it kind of uphill. Up the slope of the crater, and whether that slope had anything to do with it, I really don't know. I guess we did modify the procedure there slightly. I was pulling on the lanyard with one hand and trying to take pictures with the other. And of course I fell down there once because I tripped backing up in that soft soil.

SCOTT Yes, but you recovered gracefully.

IRWIN Well, you helped me up.

SCOTT When we finally got the thing free from the telescoping rods and the saddle, we turned it around and pointed it away from

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SCOTT
(CONT'D)

the LM so I could drive off in forward rather than in reverse. We found it was very easy to pick up and turn around. Subsequently, we moved it several times and it was easy to handle. All the pins came out and the setup went very well. Okay, the first thing that was noted in the post deployment checks was that the front steering didn't work. I cycled the switch several times and talked to the ground. We went through the various configurations on the front steering, but to no avail. However, rear steering was available. I also noticed that the battery voltage and amp readout on battery number 2 was zero. That subsequently turned out to be an indicator problem as we did have both batteries available. The seatbelt was adjusted properly. I attached it, although it took a fair amount of effort, and I drove around behind the LM to the deployment position and found that the handling was very good even though the front steering was locked in the neutral position.

IRWIN

During this time I was attempting to take sequence camera pictures of you as you drove around the back of the LM, then I met you in front of the LM. About this time, I looked at the mag and it had apparently not moved at all. This was the first indication that we were going to have problems with the sequence camera.

SCOTT

Why don't you just hit that right now since you mentioned it?

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SCOTT The whole sequence camera problems.
(CONT'D)

IRWIN Okay, we had very unsatisfactory results with the sequence camera. Out of all the ones we tried on the surface, only one mag drove. I really don't know what the problem was. I suspect that it was a film loading problem because we checked the film mags when we loaded the ETB, and they seemed to be very tight. It was hard to manually advance the film in the mags. That's about all I can say, Dave.

SCOTT Okay. And all the mags were the same way and I guess they can analyze them when we get back, but it appeared that the camera was working all right, didn't it?

IRWIN Yes.

SCOTT The LCRU came out of the MESA as planned. The indicator on the handle, which a support group put on, helped get it out without any problem. The LCRU mounted as easily as in training. The TCU was stuck in its mount in the MESA and I had to take the pallet out and then take the TCU off the pallet. But once I got the pallet out, it was no problem to remove it. The low gain antenna came out very well. The only factor there was the spool, about which the antenna lead was wound. I had to unwind the wire, and I recommend for future flights that we come up with some simpler method of stowing the antenna

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SCOTT
(CONT'D)

lead because it takes a fair amount of time to unravel all that wire. The high gain antenna came out nominally and was easy to mount. The unlocking of the antenna was easy, but relocking the antenna in the open position was quite difficult probably because of the new stiff antenna and the difficulty in the locking mechanism. I finally got it locked, but it took quite a bit of force. Cable connections worked well. I moved the TV camera over and mounted it on the TCU and I went through the procedures of turning the CTV power switch on and the LCRU switches. Then the ground called to say that they had no picture. So I recycled all the switches again and apparently the CTV switch was the clue to that problem, because once I recycled it the second time, the ground got the picture. The high gain antenna was pointed to Earth without any problem, although the Earth was very dim in the field of view, and I did check to make sure the filter was open. The ETB contents were stowed on the Rover as per planned with no problem. And that gets me down to the start up and the drive to the nav aline site which was no problem either. It went nominally. Jim, you want to go through the loading on the back?

IRWIN

Okay, the geopallet came off very easily from the LM and surprisingly, it locked on the back of the Rover without any difficulty. Contents of the SRC-1 were transferred to the geopallet. I unstowed the equipment from the pallet. I

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IRWIN fastened the gnomon bag to the back of Dave's seat and I guess
(CONT'D) we had a problem with the bottom of it coming loose.

SCOTT First time I pulled the gnomon out.

IRWIN So that requires some improvement. I attached a vise to the
 pallet, and there's only one way that goes off; and followed
 the checklist. No problems configuring the back of the Rover.

SCOTT I might add that because of the number of different articles
 that the bags were so fresh and new and stiff that it took me
 a while to get your bag on the first time because it kept
 wanting to refold to its stowed position. But that was a
 very minor problem.

IRWIN Okay, before that we had the first LEC transfer to the pallet,
 just before that.

SCOTT Oh, yes.

IRWIN I don't think it was any problem. I guess I was a little sur-
 prised it was as heavy.

SCOTT Yes, you commented on it. As a matter of fact, you had to
 work pretty hard to haul that thing up as I remember.

IRWIN I was surprised that it was that heavy.

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SCOTT Since we're on the LEC. I would like to say that we had — we divided the tasks up — and had to spend time cross training because there just wasn't the time available. We each had our particular thing to do on the Rover. I guess one man could have done it all with coaching from the other, but we had divided the tasks and the time line worked out well. I thought that we were both finished almost right on the money together, didn't you?

IRWIN It did, and we kind of swapped some of the tasks there during the early part of EVA-1 because you were tied up doing some troubleshooting, and I moved out and put the geopallet on. So, we deviated from the checklist, but as it turned out when I was ready to go up the ladder for the contingency sample, we were back on schedule and it worked out real well. I think we'd done enough training so we had that flexibility.

SCOTT In fact I thought the time lines on the surface relative to hardware loading and unloading worked out well the whole way. We were never in each others way nor was anybody ever standing around with nothing to do. Okay, I went out to the nav initialization site which was about 10 meters away, a relatively smooth place down-Sun, and gave the readout aline for the nav system, and the next step was attaching the geology tools to the harness. That went pretty well as planned. The only

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SCOTT (CONT'D) thing that I noted was, after going up the ladder several times with other pieces of gear, I feel that the LEC is unnecessary. As a matter of fact, I think it requires time and effort that's not required. I think we can do away with that. That would be my recommendation. Do you agree?

IRWIN Yes, as long as the Commander is willing to transfer the bags. And, of course, on subsequent EVAs I transferred a lot of bags up to the platform, too.

SCOTT You ever have any problems?

IRWIN No, I really didn't. I guess we had, as far as I was concerned, the worst possible problem as far as getting up on the first rung because the front strut had obviously not stroked. As far as I was concerned, the front pad was off the surface. As I initially came down and stepped on it, it was loose, and I wasn't aware of that and it tilted, pulling me back and I almost went over backwards.

SCOTT On the first EVA?

IRWIN Yes. So that was a surprise to me, and from then on it was a real struggle to get up to the first rung.

SCOTT Was it really?

IRWIN Yes. Invariably, I'd end up pulling myself up by the arms to

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IRWIN
(CONT'D)

get to the first rung, particularly if I was carrying a bag up. If I didn't have a bag, I could leap far enough to just barely get my feet on the first rung.

SCOTT

Did you have any trouble pulling yourself up?

IRWIN

No, it was just, you know, additional effort which probably raised the heart rate a little bit.

SCOTT

Well, I didn't have any problem getting up and I could get to the first rung with a leap with any bag, with a good spring. And another problem I found with the LEC was when we transferred the ETB at the end of EVA-1, the LEC line had been in the dirt and that's the dirtiest I got, I think, in the whole trip. It just spread dust all up and down the front of me as the thing went up and I guess I could have grabbed that one handle and held it, but that would have been putting an awful lot of force on you and I think that the effort expended by the guy in the cabin to hold that stuff up is not worth it. I'd recommend just taking up the bags one by one manually, putting them on the porch.

IRWIN

How about the pallet? We never transferred a pallet, I don't believe.

SCOTT

No. And I thought about that afterwards too. If you want to free your hands completely, you can have a small wrist tether

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(CONT'D)

with an elastic band on it just like in the command module and hook it to the wrist tether, and it wouldn't be any problem at all taking it up, with both hands free to hold on the rail. It would save a lot of time, a lot of dirt, and a lot of effort.

Okay, and then we started out on the geology traverse, and I guess we should probably break down again in a subdivision within the geology traverse. The Rover operations and the geology. So maybe we ought to go from here onto the checklist to the closeout and discuss the equipment closeout and then come back to the Rover.

So we did our traverse and got back to the LM for pre-ALSEP deployment and I guess we can go through the ALSEP.

IRWIN Well, at some point along here, I think, your yo-yo failed.

SCOTT Yes, I'm not sure exactly - oh, it was out on the first station at Elbow Crater when we started doing that radial sampling. I was holding the tongs and I looked down to see that the yo-yo string was still connected to the tongs. It had broken at its base. The remainder of the flight I kept asking myself why we had string rather than cable, but I figured it had been all worked out prior to flight. It looked to me like the string came untied or it broke right at its connecting

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SCOTT
(CONT'D) point within the yo-yo. Then yours broke somewhere along the way. Do you remember where?

IRWIN It was some time during the ALSEP deployment, as I remember. Initially, I had the tool tethered there; at some point I had taken the tool off and I was looking for the yo-yo and I couldn't find it. So it was some time during the ALSEP deployment it broke off.

SCOTT Yes, because we attempted to exchange yo-yos after EVA-1 so I could have it for the tongs. And when we went through that operation, we found that yours was no longer intact either.

IRWIN Yes, I might make a note that we had my yo-yo on the right side because I'd hoped to use it to secure the extension handle on the scoop. That seemed to work okay for tethering that equipment and still using it while it was tethered, but it really was a problem as far as fastening the seatbelt in the Rover.

SCOTT Okay, that puts us back at the LM ready to unload the ALSEP. The restowing of the geology equipment was rather straightforward, no problem there, as I remember. We unloaded the ALSEP packages and we had not planned to use the boot. They were tilted at the right angle, so they slid right out into our hands with no problem at all. I thought that was a slick

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SCOTT
(CONT'D)

operation. The drill came out very easily; it was easily stowed on the LRV; the LRRR came off the pallet without any problem, even though we were on a slope. I stowed everything on the Rover, and I was ready to go, I think, shortly after you were ready to go. Did you have any problem with the rest of the ALSEP? Oh, didn't you have trouble getting the UHT out of its mount?

IRWIN

Yes, but two of them were secured together, kinda locked together, which we hadn't seen. I don't know whether it was a thermal problem, or what it was. But the two UHT were kinda stuck in that bracket. We had some difficulty getting them apart.

SCOTT

I'm not sure why they were stuck. It wasn't apparent but they were really stuck for a while.

IRWIN

I also had some difficulty in getting the sequence bay doors closed; I had to cycle them, I think, three times to get them fully closed. I don't know why they were hanging up, but I did get them closed. I guess we were then ready to carry the ALSEP out. I tried to carry it in my hands and I realized that that would really tire my hands, so I ended up putting it up in the crook of my elbow and carrying it in that position out to the ALSEP site. And that was an easy task. It seems like I got out there about the same time you did.

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SCOTT Yes, we arrived there about the same time. I was surprised how easy it was to move with the ALSEP.

IRWIN Did you see any swaying motion at all — of the package? It seemed like it was pretty steady.

SCOTT It looked pretty steady to me. It looked like you were making pretty good time, but I couldn't go very fast because of all the little craters around there, subtle craters going up and down. I wanted to make sure I didn't drop anything, although the seatbelt held the LR tube and the drill very well. Okay, we're at the ALSEP site and we picked a site which was relatively level, and I think an acceptable site, although it was difficult to get completely away from some of these little craters. We parked the LRV as prescribed and proceeded into the ALSEP deployment. The major problem was the drill, so you want to go through that?

IRWIN Okay, I attached the RTG tape and there was some question on the shorting switch reading that I was never completely clear on. I cycled the shorting switch, gave them the reading, and we pressed on. They said that wasn't really important. SIDE came off; legs deployed; I set that on the surface. We removed the carry bar, stowed that. PSE was deployed west of the central station. There was no problem there. As we remarked before, the surface soil was very soft. I spent a few minutes

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(CONT'D)

stomping down a place to put the stool, but it alined very easily. Solar Wind was deployed; no problems there. It was easy to aline the shadow correctly; door was open. Then the next operation was the magnetometer. It came off freely. It was taken out to its deployment site and there were no problems there. Then it was back to the central station, and I alined it with the shadow before I started to release the sunshield. I guess the first problem that I encountered there was when I tried to release the pins that hold the rear curtain cover. When I pulled on that cord, or string, it broke and I could not release the pins. Now, there's a string that goes from one pin to the other. I tried to put the tool in there to release both pins, and the cord again broke; so I was forced to physically get down on my knees and pull them out by hand, and fortunately they came out. That could have been a real glitch because unless that's off, you can't get to the Boyd bolts on the back side of the central station. From that point on, I released all the Boyd bolts, and very surprisingly, they all released and the central station erected per checklist. I installed the antenna mast, the gimbal and I leveled it, and I guess the time to level it was about the same as what I'd been spending in training, a little more than I would like to spend. It seemed like the central station wasn't very stable, because every time I adjusted it the bubble would move back

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IRWIN
(CONT'D)

and forth, but I did get it level. I alined it, put in the settings per checklist. Then I attempted to take the SIDE out. I had trouble with the UHT locking into the SIDE. I didn't realize this until I got it just about out to the station, and I was about to put it down when it dropped off the UHT. I hope it didn't interfere with the experiment itself. I tried to engage the UHT again and again had problems. It fell off the UHT about three times there. It was very frustrating. I don't know, maybe there was some dirt on the UHT that interfered with the engagement. We got the screen down, got the SIDE positioned, pulled the safety pin, checked its level, and alined, reported to Houston, went back to the central station, and depressed the shorting switch. I couldn't really check amps zero because there was just too much dust on the gage. Might make a comment here that the dust covers that were put on the various experiments, really paid off because we were in probably the worst situation that I've seen as far as dust and soil, but they kept all the Boyd bolts clear of any dust. The ground requested transmitter turn-on, and we were running out of time at about this point. Then Dave moved in and started taking the pictures. I'll end it there. Dave, you pick up.

SCOTT

Okay, the unloading of the Rover at the ALSEP site was nominal. Went to the heat flow pallet; that came out fine. Connected

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SCOTT
(CONT'D)

the central station; worked all right. When I went to remove the probe box from the pallet, the right rear Boyd bolt hung out and I had a difficult time getting that to disconnect. I finally got it disconnected, and taking a look at the two-probe parts of the box, I found that the rammer was in the left probe box and, in training, it had always been in the right. One of the things we had attempted to do was make sure that the lines were not crossed. As I remember I unraveled the lines to make sure they weren't crossed and deployed the two probes, one to the south and one to the north according to the diagram. Then I went back and removed the electrical box, and again I had a problem with the right rear Boyd bolt, the one closest to my right foot, getting it to disconnect which it finally did. Got the box off and put it down and alined it, and it was no problem. The next operation was the drill. Drill procedures worked very well, was unstowed from the treadle and I brought over the first probe which, in this case, was the Etham probe. I proceeded to attach the drills and start the drill. When I got the first two stems in, why, it was apparent I was hitting something very hard which, subsequently, I really think was bedrock. But the first meter was quite easy to drill and then it was very difficult to get the stem any farther. I got about two-and-a-half stems in and, in trying to remove the drill, the chuck had frozen, and I think that's because of the high amount

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(CONT'D)

of torque put on the stem themselves and the chuck just biting into the stems and locking up. We'd never seen this in training nor had we ever seen any material that was compacted or as hard as that material I was trying to drill in at that time. The recommendation from the ground that came up subsequently was to drill slower which was a good idea, and just let the drill do the work. We should have probably discussed that possibility before flight because I hadn't really thought about it. That seemed to help get in a little ways. It did on the second probe. In order to get the drill off the first probe, why, I had to get the vise, the little wrench off the treadle, or off the stand where the drill stems were, and get down on my hands and knees and force it off. I finally ended up physically breaking or bending the top half of that third stem to get the drill off. But it did come off and that was a good call from the ground. I had never practiced that in training. I took the probe, the heat flow probe, and inserted it into the stems, measured it with a rammer, and after that the ground had recommended terminating drilling at that point because of the hardness. I think they called us off it this time as I remember. They said okay that's enough for that side. Or did I go in then and plant two sections? Yes, I guess I went back over to the other side, to the western side, and put two stems in over there, or a stem and a half. Again

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(CONT'D)

the drill locked up on the stem. I was having difficulty getting it off and the ground called a halt to the drill at that point on EVA-1. They said they would like to review it and see what would be the best thing to do. In my mind, I thought at that time we should go ahead and dig a trench and put the heat flow probes in the trench, as we had discussed prior to the flight, if the drill didn't work. It seemed to me that the amount of time being invested in that particular experiment was already becoming excessive. Because of the ground calling, wanting to reevaluate, I terminated drilling at that time and proceeded to deploy the LRRR and take the ALSEP photos. Before the flight we found that during our training sometimes we'd finish at different times, so we planned to use the LRRR and the ALSEP pictures as a buffer, and that was a good plan because I had the procedures in my checklist, and I had only deployed the LRRR once, I think, during our training, and I had never taken the ALSEP pictures. I did have in my cuff checklist all those procedures and they came in very handy because they were straightforward and it took very little time to deploy the LRRR and take the ALSEP pictures. I could do that while you were finishing up. I think, in the end, we ended up at just about the same time. And I got all the ALSEP pictures with the exception of the heat flow, which I didn't take because I could see then, we weren't through with it yet.

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IRWIN I might make one comment, Dave. You know, coming back to the LM in preparation for the ALSEP, I felt that I was thirsty and kind of hungry, and I tried to get some water out of the water bag as we were approaching the LM. Couldn't get any water out of it, but the food stick was there and I gobbled that down. I think that was the thing that pulled me through and gave me the energy to get through the ALSEP deployment. That really perked me up. I felt great after that.

SCOTT That's a good point. I, too, when we got back to the LM, tried the water and the food stick, and my water worked fine. I got several gulps of water. It was very refreshing and I ate about half of the food stick at that time. That helped quite a bit. I think in looking at it, the problems I had with the water bag were related to tie-down to the neck ring with only Velcro. On the second EVA, that came loose and I could never get to the water bag because it caught under my chin. I think, maybe, if we had snaps in there, or some firmer method of tying it down, it would have helped me. Can you sort out why you couldn't get to the thing?

IRWIN I could get to it. I just couldn't suck the water out. I just couldn't make the valve operate.

SCOTT I'll tell you, the water bag is really a valuable asset because one quick swish of water and it really refreshes you. I think,

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SCOTT
(CONT'D)

if you really got thirsty, you could stand there and drink the whole thing, if it worked right. There was no problem putting it in the suit, no problem donning the suit with the water bag full, or with the food stick. That gets us to the end of the ALSEP with a somewhat incomplete drill operation. I took the LRRR a good hundred feet away because of the interest in keeping it clean and the ALSEP was deployed somewhat north of my line of sight in order to get to a level spot. So I took the LRRR farther south than we had planned in order to try and keep it out of the trajectory as we took off, to keep the dust off of it. Another problem along this way was, I didn't have a yo-yo, which complicated things relative to working with the UHT and the drill. It took both hands to drill and it took the UHT to disconnect all the Boyd bolts. I ended up just sticking it in the ground and it didn't seem to hurt it any. Okay, back to the Rover, and driving back to the LM. Did you ride back or walk back?

IRWIN

I think I walked back.

SCOTT

You walked back. Because of all the craters we couldn't drive very fast and it took a fair amount of time to get on the Rover. The closeout went fairly smoothly. We excluded the polarimetrics because of the time problem. As a matter of fact, we did very little other than just gather up the samples

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SCOTT (CONT'D) and the film, load them in an ETB and ingress. I think this is the point at which I transferred the LEC and SRC with the LEC and got all dirty.

IRWIN I think we only had the SRC and one rock bag.

SCOTT One rock bag.

IRWIN Bag 4.

SCOTT And the ETB.

IRWIN Yes.

SCOTT That gets us in after EVA-1. Think of anything else on that, Jim?

IRWIN One small comment as far as alining the central station after it has been erected. It's quite easy to do. I don't know whether it was just the soft soil where we had the central station, or whether it was typical one-sixth g. Even though it's erected, it's easy to shift to line up the shadow device.

SCOTT Oh, yes. That reminds me of alining the electrical box on the heat flow. After the initial alinement and all the shuffling around there with the probes and all, at one point I tripped over one of the wires to the probe and I moved the electrical box from its alinement position. I think the ground called up

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(CONT'D)

and asked some question relative to the position of wires or
Boyd bolts around the electrical box. Maybe they were trying
to get data, and the thing wasn't properly alined. I did
realine it after we went out the second time.

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10.4 EVA-2 EQUIPMENT

SCOTT At the beginning of EVA-2, we loaded the Rover as planned. I don't remember any anomalies. I'll go through my events here. The first thing that I did was to change the LCRU battery, and that went very smoothly. It's very easy to do. We attached the geology equipment to the harnesses on the PLSS, and I had no problem there. We proceeded on to EVA-2 traverse. Got any comments on that?

IRWIN Because of my antenna problem, of course, we did not deploy it. As far as the storage of the LCRU battery the plus Y footpad was in the sunshine, so I changed it there and put that battery in the plus Z footpad, which was a change. I wrapped it in the blanket and put it in the plus Z. Then I configured the bags per the checklist. We had at least one extra bag under my seat, but I don't believe there was any confusion because the bags were clearly labeled.

SCOTT I think the ground did a good good job of keeping track of all the bookkeeping for us. With all that equipment, that was a good thing to have everybody on the ground keeping track, because we didn't have to worry about the way things went and because it could get very confusing.

We started and drove and proceeded on the EVA-2. One of the

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SCOTT
(CONT'D)

things they were looking for at the end of EVA-2 was Station 8 and a return to the ALSEP site. Since that's related to surface hardware, why don't we step ahead to the return to ALSEP site and the attempt to do a Station 8. You discuss the things you did at the ALSEP site when we go back, and I'll go through the drill again.

IRWIN

Refresh my memory. I don't think we did a comprehensive sample.

SCOTT

Not at the ALSEP.

IRWIN

We didn't do the double core, and we didn't do a pan. The first thing I did was configure for the start on the trench, and we didn't have all the photos. I started digging the trench.

IRWIN

I dug it about 18 inches deep. At that point, I encountered a very hard subsurface layer, and it was of adequate size so it would accept the penetrometer. I collected the contingency sample.

The SESC. We filled that. I don't know whether you were there when we filled the sample bags for the geology sample or not. Or did I do that myself?

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SCOTT I think you did that yourself. You did all the penetrometer yourself. That was an interesting departure from our pre-flight plan, because we had planned to do the Station 8 together. I had all of the procedures in my checklist, since I just walked you through them, as far as you doing them. Apparently you made out all right without having all those detailed procedures.

IRWIN I had just enough abbreviated details that I could follow it through. I got all the penetrometer tests at Station 8. Then I went down and took pictures of all the activities, the Rover tracks, and the ditch or the trench. Then, they asked me to take pictures of the heat flow. I did that, and I also took a pan at the ALSEP site. They asked for those additional photos. That concluded my activities.

SCOTT I went back to the drill and proceeded to implant another stem in the second site. They suggested drilling very slowly so the chuck wouldn't hang up, which I did after I finally got the drill off with a wrench again, and which required about as much force as I could give it. The wrench worked pretty good, though, at that point. I finally got the third stem at the western site. The ground suggested that was plenty and to put the probes in. This I did, and I was surprised that the probe didn't go in any further than it did.

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SCOTT
(CONT'D)

I was surprised at the indication on the rammer, and the ground subsequently called up and said that's as far as it should go in. I'm still surprised. I thought it should have gone in farther, but I guess they had it all figured out. From there I went and realigned the electrical box with the UHT. I proceeded to take the drill back to get the core. At this point, it was time to take the chuck off the drill. I took the wrench and put it in the opening in the chuck, and I couldn't get the wrench to engage the chuck. It just didn't fit. I finally took the corner of the wrench and bent open the little ears that hold the chuck on the wrench, and I got it off the way by unscrewing it.

IRWIN

Let me make one comment relative to the penetrometer. The ground plate would not stay extended. It seemed like the tension in the cable was too great, and it would always work its way back up about 3 inches from the fully extended position.

SCOTT

The next order of business was drilling the stems for the deep core. As I started out, the soil was very soft, and the drill went very easily and too fast down to the bed rock. The ground gave a call on the rates, which I had forgotten in my haste to finish up the drill. We were supposed to go an inch per second. I got about a stem and a half in before the ground reminded me of the rate, and I slowed it down to

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(CONT'D)

an inch per second. I hit bed rock, or the very hard soil, which was a step-jump in hardness as I drilled. From that point on, it was easy to drill on at an inch per second, because that's about as fast as I could get it in anyway. I could feel layering as the drill went in. Some places, it was easier to drill than others as I went through. As a matter of fact, in some places, the drill pulled me down. I could just feel the drill pulling right through the underlying material. I got all the sections in, and I noted in the process that it was more difficult to screw the sections together than it had been in training. I don't know whether it was the thermal problems, or what, but it took quite a bit of motion and patience with them to get the stems all the way to the joint.

When I got the drill all the way in, I attempted to pull it out, and not surprisingly, it was very difficult to pull out. We expected that from our training. In certain cases during training, people observing in shirtsleeves couldn't get the drill out of the ground at the Cape. I wasn't at all surprised to find that, after having drilled through bedrock, I couldn't pull the drill out. I got it maybe a foot back out, and at that point, the ground recommended coming back another day to finish. I was somewhat sorry to see that we couldn't

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SCOTT (CONT'D) get it out any easier than that, because we'd invested so much time in it, and it seemed like a shame to lose that time. On the other hand, there was a question in my mind as to whether we should spend any more time on it at all because of the amount of effort involved.

IRWIN At that point we tried another grand prix - drove the Rover.

SCOTT That's right.

IRWIN Before that, on the way back from the Front, I think we hit one mag that did work. It was mounted on the Rover, pointed straight ahead. I think that mag did drive, and I think we probably got the pictures on that. When we tried the grand prix at the ALSEP on EVA-2, the film would not drive.

SCOTT The LM closeout was nominal.

IRWIN We picked up the activities that we missed on EVA-1; namely flag deployment.

SCOTT That was the only thing we really picked up because I never did get to the polarimetric photography.

IRWIN I did the pans around the LM. I did the engine bell photography. I think that's when we deployed the Solar Wind.

SCOTT No, I deployed the Solar Wind at the end of EVA-1.

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IRWIN That's right.

SCOTT And that was fairly straightforward. I guess we got the engine sample there too.

IRWIN Yes.

SCOTT The contamination samples from the engine.

IRWIN That's all recorded. I don't think we had any problems with any of those things. Once we got to them, they worked fine.

SCOTT We cleaned off the tool harnesses with no problem. I unloaded the ETB, and I guess we ingressed again without any problem. Did you remember anything off-nominal?

IRWIN Let's go back to closing the SRCs. The SRC-1 was very difficult to close, to lock the handles. I ended up pounding on both handles to get them locked. Then when I got around to SRC-2, I had about the same difficulty, and you came over to help me.

SCOTT Yes, I tried to do it too.

IRWIN We found out subsequently that, apparently, part of the bag was caught in the rear hinge.

SCOTT Subsequently being now. It looked to me like the lid was

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SCOTT closed on the seal.
(CONT'D)

IRWIN In the front. Yes, but we never looked at the back of it.

SCOTT I didn't either. I should have. It looked like the handle was just mismatched completely from its lock. There was no way we were going to get the lock over the handle, because it was too far away. Yet, the front looked like it had been sealed.

IRWIN We couldn't get the same box stowed. We couldn't get the rod and the pins engaged in the side of the bulkhead on the LM to stow that box. So we eventually lifted off with that box sort of loose, although I put a piece of tape across the thing. But we never could get that box stowed.

SCOTT That was probably the reason — because the hinge wasn't right.

IRWIN But it was the upper SRC. You wouldn't think that would interfere with the engagement pins.

SCOTT Well, it never got stowed in the LM.

IRWIN It was very warm too. I was surprised how hot the SRC was when we got it in.

SCOTT That's right. It really was. Let's get your camera on

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SCOTT (CONT'D) EVA-2. Your camera stopped, right? On EVA-2, because we worked it over that night and then - -

IRWIN Yes, you got it to work that night.

SCOTT - - and I guess the problem with the camera — we brought it back for the people to look at - - I think the problem is definitely dirt in the drive mechanism. I fiddled with it that night and got it going. The next day, it hung up again. After we got into orbit, we worked on it some more, and you could see that the wheel exposed by the Reseau plate was hanging up. If you put your fingernail in there and triggered it, it would get going. I think with the amount of dirt that you have, and the fact that the camera is level with the area in which you work when you roll up the bags, you get dirt, in the camera. I think we ought to put some little Beta booties over the top of the camera to keep it clean, at least over the joint there where the film mag goes on. They were getting so dirty that every time we reset our f-stop and lens, I had to brush mine off with my finger. I had to wipe it off, because I couldn't see the settings on the camera, it got so dirty. I'd recommend maybe Velcro tabs and a little piece of Beta right up on top of the camera to keep that mechanism clean.

IRWIN Dust accumulation also gave a problem as far as removing the

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IRWIN film mags from the camera. There were several times where
(CONT'D) it was very difficult to release it.

SCOTT I think the camera would be better off if we'd protect it a little bit better. We used the lens brushes on the cameras, and they were very good.

IRWIN On the TV also.

SCOTT On the TV also. That lens brush is really a good brush. It cleaned it off very well. The dust brush, to clean off the suits seemed to work pretty good. It got the gross dirt off. It didn't get everything. I guess it also worked quite well on the LRV and the LCRU mirrors — cleaned them off pretty well.

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10.5 EVA-3 EQUIPMENT

SCOTT With our new plan, we headed for the ALSEP site and the drill again. The object was to extract the core and bring it back. We spent an awful lot of time doing that. Loading the Rover wasn't any problem.

IRWIN It wasn't nominal because we had your bag on the back of the tool carrier for the drill operation.

SCOTT Other than the shuffle of the bags, there weren't any problems with the equipment. We finally extracted the core stem. Each of us had a handle of the drill under the crook of our elbow, and we got it up to the point where we could put our shoulders under it. Then with each of us with one handle of the drill on top of our shoulders, we pushed as hard as we could — it must have been at least 400 pounds — and finally got it to move and got it out. Because of the significance of drilling in the bedrock, it was probably the way to go. We could only accept the ground's evaluation, but at the time, it seemed like we were investing an awful lot of energy and time in recovering one small experiment, however important it may have been. But at that stage, I guess we had so much invested in it that we couldn't afford to leave it. It sure was expensive. When we got it out, we put it up on the back of the Rover on the geopal-let and attempted to break it down with a wrench and the vise

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SCOTT
(CONT'D)

mounted on the geopallet. The vise on the pallet just didn't work. At first, I thought it was on backwards. I knew darn well we'd discussed it before and that it could only go on one way, but I just couldn't believe it was that bad. It just didn't grip at all. Jim got on the other end of the stem and moved it horizontally and vertically, and he put every kind of torque on it I think he could, to try and get it to lock in there. The hand wrench worked fine. It would grip the stems and hold them very well, but the one mounted on the pallet provided no torque at all. I guess we got a couple of stems. I don't know how we got a couple of them loose, but we got enough. We got three stems separated and ended up with three stems joined. We capped them, called out the caps, and took them back that way, but that was a real chore. We fiddled around with the treadle some. That was somewhat of a chore also, but I think that is inherent in the design of the equipment. If the drill works as advertised, it really isn't bad, but in summary, the ground being very hard tightened up the drill stems much harder than we'd seen before, and the vise not working on the back of the Rover complicated the extraction, or the separation, of the stems. Finally, we had the number 4 stem off about half way, and I finally, just in gripping the thing, unscrewed it by hand.

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IRWIN I'd taken my protective covers off my gloves before I even went out on EVA-1 so, of course, they were off for this operation. I was kind of reluctant to grasp that drill very hard, afraid I might rip the gloves.

SCOTT That's a good point. I had to leave mine on the whole time because of the drill. The protective covers can restrain your hand movements even more than the gloves. I had sort of degraded mobility because of those protective covers, all the way. I finally took them off after we got through with the drill. The LCRU battery change was nominal. We got back to the LM and started the closeout. I don't remember anything that did not work at this point. We unloaded the Rover, and I proceeded to drive it out to the TV site. I don't remember any off-nominal conditions there or any hardware problems, do you?

IRWIN No.

SCOTT Ingress. We had a number of bags to carry up at that time — two collection bags, the BSLSS, and the ETB.

IRWIN And the core stem.

SCOTT I carried all those up by hand. You took a couple of them on the way.

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IRWIN I had two bags plus the core stem up on the porch.

SCOTT That's right. And all those went in all right. One thing I want to add. I asked you to check me to see if my PLSS was loose, and you couldn't see anything wrong with it. I had the distinct feeling the lower straps were disconnected from the PLSS because it was bouncing on my back when we got to the LM. When I got off, I could feel it bouncing on my back, and I never did figure out what that was. I just went slow, and when I walked back from the Rover, I took very small steps that kept it from bouncing around. During the bouncing steps that we were using, it was really flopping back there.

IRWIN Well, you hadn't walked much before that, had you?

SCOTT I would have noticed it before because of getting on and off the Rover. I noticed when I got off the Rover that time it banged on my back, and that's why I asked you to check it. I still don't know why it felt loose.

IRWIN I retrieved the Solar Wind. It really had so much of a set that it wouldn't roll up properly, and the bottom part of it ripped. It was just like in training.

SCOTT Really?

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IRWIN Yes. But I was able to manually roll it up with my fingers, trying to avoid touching the foil itself, and put it in the ETB. The bottom of it did rip. I retrieved the penetrometer drum. I took care of all that before you drove off. I don't know, did you take all the tools off the Rover, or were they still on the Rover when you drove off?

SCOTT I left them just as you replaced them.

IRWIN They were all on the Rover.

SCOTT Yes.

IRWIN That was one period where we probably could have collected another 50 pounds of rock if we had wanted.

SCOTT You're right.

IRWIN We didn't plan that too well.

SCOTT I don't think we had planned on having that much time when we got back to the LM. I think we really got called back too soon, because once we got back there, we really had more time than we had ever planned on for that closeout. Therefore, I think we wasted a lot of time. I remember when I was out at the Rover, I could see you back at the LM just watching me.

IRWIN Yes.

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SCOTT You could have been collecting a whole bunch of rocks at that point.

IRWIN I spent the time transferring as many bags as I could up to the porch, but there was still plenty of time left to collect maybe 50 pounds more of rocks.

SCOTT They got us back too soon. We wasted considerable time back there. I had the distinct impression people were getting awful itchy about us getting back in time and getting closed out in time. We felt pretty warm about that final closeout because we had run through it so many times, and we knew that we could handle the time line as prescribed. We never did have a problem. Once we got back to the LM, we always had plenty of time to get everything done.

IRWIN The unknown was your taking the Rover out to the right position and getting all that taken care of.

SCOTT Rover procedures. I left the NAV system in RESET. That's what it was. It says NAV system in RESET, checklist, and then drive to a heading of 096. I had left the NAV system in RESET, and I got half way out to the Rover site for the TV, and I looked down and it was still zero as it should be if it is in RESET. Then I realized it didn't make any difference, because had I gone to the exact position, I'd have probably been down

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SCOTT
(CONT'D)

in a crater because there were so many out there. So I took it to a high point which was like a tenth of a kilometer away, and I think in the final analysis you got pretty good pictures of the lift-off. It was probably better just to select a point somewhere to the east of the Rover that would give a good TV vantage, rather than try and be precise on the distance and the heading, because there are so many craters out there that we might have been in a hole anyway. So that, in the long run, worked out all right. I think all you need to know is which way the Rover needs to be pointed, relative to the LM, so you can get good TV. When I got out there again I had problems alining the antenna. The ground desired to have us pointing down-Sun for the TV. That meant that when I pointed the antenna, I had to look up-Sun because of the position of the high gain on the Rover. Looking up-Sun, I just couldn't see the Earth. In the pointing device there, it was just too dim, even with the sunshade extended and the filter up and open. About 50 percent of the time, I used the AGC signal strength to get an indication that I was pointing to Earth and just sort of visually eyeballed the thing. It would be a significant improvement if they could open up the light passage through that sighting device. I had the same problem when I got the Rover out to aline it the final time and in trying to get the Earth in the exact position in a field-of-view for subsequent

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SCOTT
(CONT'D)

TV programs. I finally did find the Earth and got it alined according to the checklist. The Rover was left in the prescribed position with circuit breakers as planned. Then back to the LM and INGRESS. That's about the sum total of the hardware operations on the surface. This summarizes the tool operation — mechanically — how they work. They all work just fine. When my palms got dirty, I had a difficult time manipulating the handle squeeze and the opening and closing because of all the dirt in the tongs. And so, about half way through EVA-2, I switched to the other set of tongs which were clean. That helped quite a bit. The problem in not having a yo-yo is that I had to stick them in the ground while we were gathering the samples. The cameras mountings — taking them off the RCU, seemed to work fine. The 500 millimeter worked fine. I used my helmet shield as a base to steady it. I noticed it made some light scratches in the gold material, but it didn't really bother it. How about the extension handle with the scoop? Did it all work okay?

IRWIN

It worked fine, and digging the trench went much faster than I had expected. I estimate, in 5 minutes I had the trench dug. Then, of course, the TV caught the action as I used it. The connector for the dispenser sample bags came off of my camera once.

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SCOTT Oh, did it?

IRWIN Yes, I retrieved it. It was on the ground and I picked it up. It was a good thing I used the tongs to retrieve it and put it back on. It stayed on for the rest of the time. The operation of the rake went just like our simulations in the K-bird. It worked good for collecting the rock fragments as well as for transferring the soil. I thought it went real well.

SCOTT The gnomon worked okay. The gnomon bag worked okay, except for the problem of having the bag disconnected all the time, which we also experienced in training.

IRWIN A comment on the stowage of the scoop on the extension handle. Rather than tethering it, we mentioned already that the yo-yo had come off. So I just positioned the scoop extension handle on the left-hand side of my seat, kind of under the bracket, at the attachment of the seat to the Rover frame. It did ride fairly securely there.

SCOTT I took the tongs and stuck them under the left-hand side of my seat between the seat post and the bag, and they rode very securely there, too. Lets see, the core tubes worked fine. It was the first time we'd ever seen the core tube caps and they were a little different. I got the impression they were a little harder to put on, but once they were on, they stayed

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SCOTT
(CONT'D)

on better. I would recommend that the future crews get to see the flight hardware some time before the time they arrive on the lunar surface. But they worked all right. We never had to point the low-gain antenna. I mounted it in a not-quite vertical position. As a matter of fact, I mounted it as it was stowed and never had to change that, which was nice. The covers over the LCRU battery worked fine. We could put them in any position required in the checklist, and they stayed. The Rover battery covers didn't close automatically one time. They were relatively easy to operate manually.

IRWIN

I guess we commented about the general dust condition on the Rover. We just took one series of pictures of the dust accumulation on the Rover after the EVA.

SCOTT

Certainly. I got a picture of it there at the end when I parked it, which will show it. The geopallet gate worked fine. It looked to me like there wasn't any problem with that. Hanging the bags on worked all right. We had a little problem with the bag on the inside of the geopallet between the seats and the pallet — getting it locked.

IRWIN

The BSLSS bag. We had trouble getting that locked. I think that's because the bag was larger than the collection bags, and you just couldn't get your finger in there with a suit on to get it locked. Wasn't that the problem?

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SCOTT Yes.

IRWIN In order to get it unlocked there, I ended up jumping up on my seat and reaching over to get it unlocked. I guess the vise was really in the way, to some extent. It didn't give.

SCOTT It was only that one bag that we had a problem with. That finishes up the hardware part.

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10.6 EVA-1 GEOLOGY

SCOTT We'll start out on the geology portion of the EVA number 1, and I guess we'll organize it relative to discussing our general impressions on the geology as we went from station to station. At each station, we'll discuss our general and specific impressions and try and go along with the actual traverse that we conducted, rather than related to the planned traverse. I guess I might make a general comment in looking at the map of where we apparently actually went, which is a preliminary event in order for us to have a reference. I think the time we made on the Rover throughout the excursions was as good as we expected, and probably better in between stations. With the problems we had on the surface, we lost some time in between EVAs, but I was very happy with the Rover performance. I think we probably had planned more than we could ever have accomplished, as far as distance was concerned, if we were to spend any time at the stations at all. I thought the stops were, in general, fairly efficient. We didn't have any hangups in the procedures or the equipment, as far as the geology goes. I don't know where the time went. I guess it went on ALSEP. We didn't cover as much as we had expected to prior to the flight, but I feel we covered as much as we could have in the time allocated. I was very

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SCOTT
(CONT'D) happy with the Rover traveling speed. I think the geology tools and the concept and manner of sampling were just fine. Didn't you?

IRWIN Yes. No problem.

SCOTT We did everything we could have done in the time allocated, and there weren't any particular hangups. Shall we start out driving down on EVA-1 toward the rille? The ground called us and said to skip Checkpoint 1 and go right on down to Elbow. Our general technique was for me to drive and keep my eye on the road as well as was possible. Jim would do the navigating and commenting on what he saw geologically, and if I had a chance, I'd fill in a comment here or there on the geology. Jim really did most of the navigating and discussion. Most of the stuff is on the tapes, I'm sure. Why don't we head on down south, and why don't you make your comment there on the traverse to Elbow Crater.

IRWIN We were supposed to be looking for a possible ray, and I saw no evidence on that leg of any ray. I didn't see any lineaments. There were probably frequent fillets around rocks, but I did not comment on them. I did not see any mounds, didn't see any mounds at all in the entire area.

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SCOTT No, I didn't either. Never saw what would be comparable to an Apollo 12 type mound.

IRWIN We were looking for a raised rille rim or a levee, and I think we commented on that later on. There might have been suggestions of just a very slight end of maybe a levee. I think that was more evident on EVA-3, really, rather than EVA-1. The block distribution, I didn't see any pattern at all, other than distribution related to individual craters. I didn't see any difference as we drove down there.

SCOTT Occasionally we'd see a block - not a block, but a large fragment. I wouldn't even call it a block, a "foot" kind of fragment, like the one we ran over. That was an occasional kind of thing.

IRWIN Again, that was associated with a particular crater, I think.

SCOTT Yes. Probably was. We didn't see the excavation of bedrock by 25-meter craters. We did see some fresh craters that size, but the general surface was very hummocky and had a relatively heavy crater density, but all subdued and rounded with low rims, no raised rims. But they were larger than 25-meter craters which had not excavated bedrock or showed no signs of outcrop of bedrock.

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IRWIN We were about a half a kilometer from Elbow when we saw the rille, and at that point, I think we were heading a little too far southwest. We changed our course a little — swung around to the south. And we did that, a short while later, we could see Elbow very plainly. We then headed toward Station 1.

SCOTT We might have been pretty close to the first leg of the EVA-1 traverse on the map, which shows us heading more south-southwest than south, because we did see Elbow Crater from the side of the rille, quite a ways away. And there again, I think the distances were somewhat deceiving and that it looked closer than it really was. When we did see Elbow Crater, I felt like we were almost there. Then there was a fair amount of driving before we got there. Everything looked closer, and as I look at our landing site, relative to Pluton, I would have thought Pluton was just right around the corner from the site. I think the distances, again, as everybody has said in the past, they're really deceiving up there with no other objects to measure and compare. On the lineament thing, you and I both discussed that. I think you can see lineaments if you look for them. That's true as a function of Sun angle and the angle at which you're looking, because you can imagine them in almost any direction. I could almost say there are

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SCOTT
(CONT'D) lineaments anywhere, if I really used my imagination, although some places they appeared more evident than others. I saw one place where it looked to me as if they were running along the lunar grid, northeast-southwest, northwest-southeast.

IRWIN I guess it was on EVA-3 where I really thought I saw them. Down on the edge of the rille. I saw them parallel to the rille and perpendicular to the rille.

SCOTT I think I saw them on EVA-2, driving back. The distribution of soil, grain size, and that sort of thing indicate the ray. I didn't see any significant change of granularity for the soil at all. I think it was deeper up the side — of course, that's getting further down the EVA here — but on EVA-1, I couldn't recognize any change in soil. Could you?

IRWIN No.

SCOTT I believe you mentioned that the block distribution or fragment distribution did increase somewhat as we got to rille rim. There were more fragments.

IRWIN I'm wondering, was that a function of the rille or a function of craters there? I know that was true when we got to Elbow. There were plenty of rock fragments there.

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SCOTT I think we commented on that on the voice tapes. I guess my general impression of Elbow was that it was much more subtle and subdued than we had expected.

IRWIN You know, when we first saw Elbow, I think we were kind of downslope, down on the rille side of the levee. We saw it, and we went back up on the top of the slope. It was smoother driving there.

SCOTT You're right. Matter of fact, I think we commented at the time that it was better driving back up on the ridge line, or the raised point if you don't want to call it a levee — which, I guess, I agree wasn't really a very profound levee, if it was at all.

IRWIN We had the sense we were going up and down into these valleys as we were coming back to the IM, but you didn't have that impression as you were driving south to Checkpoint 1. So maybe this was a levee, but yet you had these undulations - little valleys - east of the rille rim.

SCOTT Okay, on the visibility of the far-wall rim, I think we had a fairly good look at that and decided that it wasn't exactly as we expected. There was some apparent layering in the upper levels, but it wasn't a clean breakout of three or four levels on our way down. And you commented, I think, when we

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SCOTT
(CONT'D) got up here, on what was called Bridge. Isn't that where you got a good look at that.

IRWIN I think it was Station 1 where I said the Bridge Crater looked more like a shallow depression on the northwest wall of the rille, but certainly not a place where you could actually drive across the rille.

SCOTT We stopped at Elbow, and I think we sampled radially, although it was a short radial sample. But I think we did pick up three separate bags of frags.

IRWIN The rim wasn't very distinct there; it was a very subdued rim.

SCOTT Sure was.

IRWIN And I guess the first sample was probably what, 20 feet or so from the rim? Hard to tell, but it wasn't right on the rim.

SCOTT You couldn't define the rim. It was a fair distance from where the slope ended and the bottom of the crater began. There wasn't a raised rim at all.

IRWIN And no bedrock exposed in Elbow. There were some rocks in the crater, but not clearly bedrock.

SCOTT That's right. You couldn't define any big in-place outcrops. I think the three samples we got there we described as we went along, and that was the one place I think we saw

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SCOTT (CONT'D) what appeared to be olivene in that rock. Remember? It was green — looked like a crystalline rock which had a lot of green in it.

IRWIN I can recall that that came from Station 1.

SCOTT I sure would like to see it again, to see if we really saw what we saw. Those visors might have fooled us a couple of times there, but it was colorful. Well, that was a short stop. I guess, we had planned to have a short stop. You got a pan here, didn't you?

IRWIN Yes.

SCOTT Did you get a pan at every stop?

IRWIN Yes, I did.

SCOTT Crater wall - stratigraphy; we didn't see any crater wall stratigraphy. I don't think we recognized any significant ground pattern around the crater. Station 2 we selected as a large boulder on the surface. It was very prominent, very unique, and it was the one large boulder that was visible anywhere in the area. I think our idea of going up to the rim of St. George Crater would not have been worth the time, because there apparently wasn't that much on the rim to tell us anything. There was no ejecta blanket, and there was no

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SCOTT distribution or increase in fragmental debris anywhere that I
(CONT'D) can remember.

IRWIN I guess, the only thing that would have been significant
 would have been if we could have gotten up to the very fresh
 light colored crater.

SCOTT We considered doing that for a while.

IRWIN Yes, you did.

SCOTT I was going to drive up there, but I think we ran out of time
 by sampling the block. That would have been a very good
 crater to sample, because it's quite visible, as I remember,
 even from orbit.

IRWIN Yes, you can see it from orbit. It was a fresh crater, and
 it was very light albedo. I just wonder if that light material
 is that very light from the anorthic site. You know, it was
 underneath the big rock and it was kind of powdery white.

SCOTT It could have been. Too bad we didn't get up there.

IRWIN Too bad we didn't get a lot of places.

SCOTT Yes.

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IRWIN Well, on traverse I was supposed to observe Elbow ejecta distribution. I think the ejecta distribution was uniform around Elbow, optimizing one crater diameter.

SCOTT Yes, but there wasn't much of it.

IRWIN No, not much.

SCOTT I'm not sure you could call that Elbow ejecta, though. I don't think we could distinguish a radial or circumferential ending of the ejection. There was just a lot of debris.

IRWIN I thought we drove out of the ejecta and it got fairly smooth again.

SCOTT Yes, you could definitely see the slope increasing as we went up toward St. George.

IRWIN I didn't see any change in rock type.

SCOTT No, there wasn't any.

IRWIN The ground texture as far as we went up the slope — well, as we looked upslope, we saw maybe a suggestion of horizontal beds from this downslope movement.

SCOTT Yes, the slide of the material.

IRWIN And I didn't see any St. George ejecta.

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SCOTT That's why I think that it would not have been too fruitful to go to the rim of St. George unless we could have gotten to that fresh crater up there. But there really wasn't an ejecta distribution per se.

IRWIN I can't think of any particular explanation of that large block.

SCOTT It didn't look to me like it came down from above. I didn't see any tracks. My best guess would be that it came from secondary cluster, or was the secondary from below. It's hard to relate to these secondaries. It did look like it came from the top. I didn't see any outcrop up there which could have produced it. Did you?

IRWIN No. I guess we'll have to look at the pictures in context.

SCOTT Yes.

IRWIN We didn't sample regularly there.

SCOTT No. We just sampled that block. I think we filled all the squares for block data. Yes, you even tried to turn it over.

IRWIN Yes. I tried to turn it over, and we did a comprehensive sample there.

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SCOTT Yes, but it wasn't very fruitful. You raked and raked and raked, and I think we got about a fifth of a bagful, because you were not shaking little rocks out earlier.

IRWIN Yes. I wonder how it came back, probably all soiled after the transport. We did do a double core there.

SCOTT And it was an easy double core.

IRWIN We did mostly soil there.

SCOTT Well, we got the boulder. We got one fragment from one side where there appeared to be a linear contact within the boulder itself. Whether it was a clase within a much much larger rock, or whether it was actually a contact, I don't really know. But, we sampled on each side of the contact. We also sampled the soil near the boulder. We sampled the fillet and underneath the boulder.

IRWIN You know, the surface soil there was very soft. It was the same textured soil as we saw on the slope down near Spur. And this related to the softer upslope.

SCOTT Another thing I remember was that the fillet was clearly on the downhill side of that boulder. There was no fillet on the up hill side, which was rather interesting. But, you could almost see underneath on the up hill side. And there was no crater as such; it was fairly on the surface.

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SCOTT
(CONT'D)

It looked like it had been deposited on the surface and the fillet had somehow accumulated on the downhill side, like the wind was blowing from upslope. I guess that other crater, that light-colored one, was almost halfway up St. George, wasn't it? We would have had a tough time getting it all the way up there. I think the Rover would have made it, but I think it would have taken a great deal of time. We came back, then, almost directly to the LM. As we drove away from Station 2, I think one of the things that really impressed me was the very gradual slope into the rille, just to the north of Station 2. It was almost a very subtle V-shaped depression or slope into the rille. I got the impression you could have driven down into the rille there.

IRWIN Very easily; just a little more slope there.

SCOTT Right between Elbow and Station 2 was a neat slope. I'd say it was at least 5 degrees less than the rest of the rille. That's why I get the impression that that's a portion of the fracture along there filled by a slide. I felt that, if we'd turned left there, we could have very easily driven down into the rille and back out.

The drive back was a fairly easy drive. We were following the NAV system almost all the way.

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IRWIN There wasn't any change in block distribution or rock distribution on the way back. I didn't see any rock flows or any suggestion of rock flows coming out of the front. Again, no pattern.

SCOTT Had we attempted to go to Station 3, we'd have picked a place somewhere and stopped, because it didn't look like we'd see contact up there. It was all too weathered. Everything seemed very uniform, as far as the surface texture.

IRWIN The only observation that we really made was the fact that we were going down in one valley and up over a hill.

SCOTT Right.

IRWIN It was quite a topographic change between one and the other. You could really have parallel bridge lines there, although very subtle. We could very easily look over the EVA-2 route and see that it was just as smooth or maybe smoother than the EVA-1 route.

SCOTT That's right. I think we commented on that at the time — that there would be no problem getting down to the EVA-2 route or driving along the Front. The general distribution of the craters was about the same. There was a wide variety of sizes, all very subdued, with an occasional fresh one which had almost

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SCOTT (CONT'D) 100 percent coverage of fragmental debris within the inner walls, and maybe a quarter of a crater in diameter out over the rim. It didn't go very far.

IRWIN With the glass portion in the center?

SCOTT Yes. That was the one we were going to sample sometime along the way, but we never sampled it.

IRWIN We sampled one along the Front — the first one we stopped at.

SCOTT That's right.

One time I had to stop and fix my seatbelt. We picked up that rounded vesicular basalt fragment that was setting there. Through the windows, prior to leaving the LM, we had seen a large black fragment on my side. And you had seen a black frag on your side, as you looked out the front window. These were unique to the local surroundings. I don't think we'd seen other fragments that black and prominent. I picked this one up; it was probably 60 or 70 meters in front of my window. When we got back we tossed it in the bag. It was about 8 or 10 inches across by 6 inches thick. It almost looked like one big piece of black glass with a rough textured surface.

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10.7 EVA-2 GEOLOGY

SCOTT We drove directly to the Front. There was a certain wander factor there as we went by Crescent and Dune.

IRWIN I saw one crater there I estimated was probably half a kilometer out. I thought I saw a bedrock exposed, probably 10 to 15 feet below the surface. They probably would have wanted us to stop there on the way back, if we could have found it. But, we never saw it on the way back.

SCOTT They commented on it, and we did, too. We could pick that one up on the way back, but we never saw it. We followed our tracks on the way back. On our way down, the surface relief appeared to me to be generally the same, a variety of crater distribution, all subtle, subdued, and an occasional fresh one with all the debris in the bottom on the glass in the center; less than 1 percent, much much less than 1 percent. When we went by the big craters, Crescent and Dune, they were really subdued. They sure weren't very obvious.

IRWIN But, it was obvious when we saw Dune. We also remarked that we didn't see that rampart on the southeast side.

SCOTT I think, we recognized Dune by the notch on the side. Although it was more subdued and there was no rampart, I think it was

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SCOTT
(CONT'D)

quite easily recognizable by that notch on the south side.

We proceeded to drive on up the slope. I didn't realize we were going quite that steeply up the slope until we got up to Station 6. Driving down there, we discussed the secondary sweep up onto the Front. It's obvious that the only craters within the Front itself appear to be due to the secondaries, because it's a straight line right up to the side of the Front with maybe a dozen craters up there on the slopes, in line with what is expected to be the direction of secondaries. I didn't see any other craters anywhere. There was a large block down in the vicinity of Front Crater, upon on the slope.

IRWIN It must have been a huge one.

SCOTT It was really big. I got a 500 of it, so maybe we'll get a chance to see what it looks like. We drove up to Station 6.

IRWIN That was one of those small fresh craters with a glassy center. We sampled the center first.

SCOTT We can sort out the rocks and easily identify them instead of trying to remember them now. It seemed like a significant stop. There were worthwhile assortments of things to be sampled. We saw Spur Crater. The idea was to stop there and to press on down to the Front.

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IRWIN Somehow, we turned around, though, instead of pressing on down to the Front. What did we do, run out of time?

SCOTT Well, time was getting short.

IRWIN It all looked the same.

SCOTT It all looked the same, except for that very large boulder down there. Other than that, it all looked the same. I didn't think we would gain anything by going in that direction that we couldn't expect to see at Spur. It just didn't seem fruitful to head off to the same type of surface that we'd been seeing all along. We had three things in this area that we could sample which were representative: a young fresh crater which we were on, the boulder which was upslope, and Spur. It appeared to me that to go any further would have really compromised the sampling at the other places.

IRWIN I was thinking that the boulder was more in line with Spur.

SCOTT No, we went up to the boulder.

IRWIN We went up to it?

SCOTT Yes. We were driving uphill to the boulder. Then we went down the slope from there to Spur.

IRWIN The large rock was on the upslope side of the crater.

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SCOTT You went up and looked at it and said it was green. I came back down to the Rover and went back up with the tongs. I pried a piece off with the tongs.

IRWIN There was a layer there.

SCOTT In the central part of the boulder there was a very loose surface covering, which could be scraped off. That's what you scraped off. You could see beneath it the lighter colored material, which we interpreted as green. I think that was because of the visors.

IRWIN Yes.

SCOTT It was really a light gray, similar to the type of material we'd seen at the rim of the fresh crater and which we sampled.

IRWIN After that, we went down to the downslope side of that crater.

SCOTT We went down to Spur. The downslope side of the first crater, at Station 6, was where we got the light albedo and where you dug the trench. We were going to trench on the uphill side of the crater. You said, "Hey, there isn't any light-colored material here." So we went back down to the downslope. That was the same material that was on that rock, although it was very loosely consolidated in the central portion of that large

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SCOTT
(CONT'D) boulder. It could be scraped up as sort of a crust material on the boulder. I scraped it up with the tongs and put it in a bag. I also pried off a chip of the boulder which appeared to be an Apollo-14-type breccia. The boulder appeared to be sitting on a surface. If I had to call that one, I'd call it the upslope from the secondary. There's where we noticed the difference in the Rover tracks and the depth of the bootprints.

IRWIN I think we photographed that. I guess it was one of these stations where we looked over Hadley and saw all the organization of the beds over there.

SCOTT Yes, as a matter of fact, that was back at Station 6 because I think we did the 500 there. Didn't we? I think I pulled out the 500 and either did that at Station 6 or at Spur.

IRWIN I think we did it at 6.

SCOTT And I got the whole organization there on the Front. I took a couple of horizontals and a vertical strip of the thing. If all that 500 works out, it will be a pretty enterprising operation. We might discuss the 500 since we're on it. We had trained with the trigger and the handle. We both decided not to use the trigger and the handle because it seemed to require enough torque to move the camera when you took the picture.

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SCOTT
(CONT'D)

So, I tried the first EVA without it and it seemed to work better. I felt more stable without the trigger and I never did put the trigger and the handle on it. I just used the straight pushbutton method. It felt fairly stable while I was taking pictures.

On down to Spur, Station 7. We did quite a few samples there. There is where we found what we're calling a lot of plage in that rock, an anorthositic rock if there ever was one. That was the one on the other rock on the sort of pinnacle. It was different. It looked white, dust covered, with white spots on it, which indicated it was different from the general gray fragments around it. There was a nice 3-foot boulder there on the surface, which was another breccia which we were going to work out way up to. We never got to sample that. I did get one piece of it. It looked like it had fallen off on the ground. I think you raked there, didn't you?

IRWIN Yes. I had a good place to rake. Good comprehensive samples.

SCOTT Yes, you got a good rake and a good soil.

IRWIN Yes.

SCOTT Okay. It seemed like that was a very fruitful place to obtain samples. I wish we could have spent more time there sampling

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SCOTT
(CONT'D) because I'm sure we'd have found more of the anorthositic type or the plagioclase. But time being what it was, we pressed on back with a thought in mind that we'd stop at Dune Crater to pick up a secondary sample and take care of that requirement.

Summarizing the observations of the rock types collected at the Front, we saw breccia and crystalline. That was about it. Did we see any good pieces of basalt?

IRWIN You mean up on the Front.

SCOTT Yes.

IRWIN No. We didn't see that until we got down on the Dune.

SCOTT I think that's right. There wasn't much block distribution. There weren't very many. All along the Front, there were half a dozen blocks that you could see on the whole base of Hadley Delta. There were no mounds. Did that big boulder we sampled up there have a fillet?

IRWIN I don't remember, Dave; you'll have to look at the pictures.

SCOTT Any patterned ground that you remember?

IRWIN No.

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SCOTT No apparent flows or slides. That takes us down toward Dune and we backtracked. We found our tracks and followed them back. It was interesting to us concerning the ground's interest in finding our tracks. Every time we headed back from any point they said, "Find your tracks and follow them." I guess there was some doubt as to the Rover nav system, but I felt very comfortable about where we were. I never felt that we needed to find our tracks. Did you?

IRWIN No. Particularly from the Front because we could see the LM.

SCOTT Another factor was the mountains in the background and the horizon. We could pick a point on the mountain and drive towards that point and we knew we were going toward the LM. I never felt disoriented or lost. I think we could have completely lost the Rover nav system and I wouldn't have had any apprehension about finding the LM.

IRWIN Yes, as you remarked, you could see Pluton all the way back; just head toward Pluton.

SCOTT We could see Pluton, and we knew the LM was on a slight rise; topographic high, anyway. So, I didn't feel tracks were necessary. As a matter of fact, I think we deviated from the tracks to find better routes or more direct routes.

IRWIN Yes. We certainly did on EVA-3.

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SCOTT Well, on EVA-2, also. After Station 4, if we had followed our tracks, we would have had to do some weaving in and out of the craters there. Let's see, in approaching Station 4, did you get the feel of any buildup on the downsweep side of the secondaries? Did you get any directional kind of feel for those secondaries? I didn't.

IRWIN No. But it was just obvious that we were coming into an ejecta pattern there from Dune Crater. Concentration of rocks increased as we approached the rim.

SCOTT But I didn't notice any grain size difference. When we talk about grain size, I don't believe the grain size change would be obvious to the eye. If there is any difference in grain size, it's probably micro because I never noticed any.

IRWIN It's hard to see when you're driving.

SCOTT We got to Dune Crater and there was one obvious boulder with large vesicles right there in the southern side of the notch that we hadn't sampled. That was probably one of the most prominent rocks we saw during the whole time.

IRWIN I saw another rock with exactly the same size vesicles right at the edge of the rille.

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SCOTT You're right.

IRWIN That was probably the bedrock.

SCOTT Yes, I'd say definitely it was bedrock. We sampled that one in the center near the vesicles, and on the edge where there were smaller vesicles on the outside of the rock. They were millimeter-size vesicles. That rock was about 6 feet high and 4 feet across, with rounded 3-inch vesicles, very clean with plagioclase laths in it which were centimeter long and millimeter wide; random orientation. In contact with that was a highly vesicular-like, maybe half-centimeter, uniform spherical vesicular rock, which was a lighter gray and had not been chipped. I took a picture of it. It's too bad we didn't get to sample it. But, it was a different flow entirely. A different rock and they were in contact.

IRWIN I remember observing that the largest crater in the south cluster was one that ran east-west. I got the impression that it was elongated that way.

SCOTT You really don't get that from the photos.

IRWIN Yes. Looking down on it from up here, it was one oriented this way (gesture). I think we'll be able to see it from the pans.

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SCOTT The other frags we picked up at Dune Crater, we just didn't have time to look at. We didn't give them a TV stop there either. When you cut down the time to the point we had it's just too bad. We spent a lot of time there, too. Then we proceeded on back to the ALSEP, and you picked up a couple of rocks back there. You picked up your black one.

IRWIN What I refer to as a pink.

SCOTT Pink.

IRWIN Pink with light plagioclase in it.

SCOTT Did it really? You got to pick up rocks while I had to drill. You have all the luck.

IRWIN We both had our thing. I was doing other things. I dug the trench.

SCOTT Yes. That I guess summarizes EVA-2. I didn't notice anything in particular driving back. You could see albedo changes where we'd been. Any disturbance of the soil was apparent. The Rover tracks were a little different.

IRWIN A little darker.

SCOTT Yes.

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10.8 EVA 3 GEOLOGY

SCOTT On EVA 3, we started out after exercising the deep core drill again for Station 9 and Scarp Crater at the edge of the rille. We had to take a circuitous driving route, going around the craters, which seemed to be elongated north/south. We were going again up over depressions in topographic highs which trended north-south. You felt like they were pretty much circular.

IRWIN I felt they were circular. Perhaps the photos will tell us some more mainly because the three circular features were all lined up there.

SCOTT Look at that this way, though. Why don't you comment on what you saw of the terrain because I was just pretty much trying to drive and to avoid the big holes.

IRWIN There was just a gradual drop down. We drove through one or two of those depressions. I would not say shallow depressions because actually the bottom was probably 150 feet below the general surface of the plains.

It was about a 5-degree angle into the bottom. I remember one in particular that seemed like a fairly fresh crater in the very center of it, with no rock debris, no ejecta on it. It

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IRWIN
(CONT'D)

was right in the center of the large, shallow depression.

There were three of those as we headed west. I did not see any change in rock distribution as we proceeded to the edge of the rille until we came up to that very fresh one which we incorrectly called Scarp, initially. It probably was Rim Crater.

SCOTT

Probably, because it was too small to be Scarp, and it was fairly fresh.

IRWIN

That was the first place we stopped — on the western side of that very fresh crater.

SCOTT

That was the one that had a very soft rim. Soil was just much softer than we had seen before. The frags that we picked up there were clods. I mean they fell apart — were very fragile.

IRWIN

They all looked the same, sort of angular, but they did have some glass in them. I guess we disagree there, for I say that crater is similar in characteristics to the very small ones that we saw earlier, except there is no concentration of glass in the very center.

SCOTT

I guess I thought there was not that much concentration of fragmental debris. The smaller ones appeared to me to be pretty nearly 100 percent covered with frags; and this, I would say, had maybe 30 percent frags.

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IRWIN Well, I thought it was 100-percent coverage.

SCOTT Did you really?

IRWIN It will be interesting to see what that picture shows.

SCOTT We may be talking about two different craters.

IRWIN I don't think so. I remember that you went on ahead because I was working on my camera, trying to get the camera to work; and you went on up the rim. You were sinking in, and I came up about 5 minutes later. I was impressed with how soft the rim was because you would sink in almost 6 inches.

That was a very unique crater. It was the only one of that size and that type that we saw on any of the EVAs.

SCOTT It surely was. I hope some of those clods got back intact because they really fell apart easily. I think the photos will describe the rim better.

IRWIN In fact, one of the photos that we saw this morning was of that crater.

SCOTT That's right; it surely was. I guess you are right. If that is the case, then that indeed was covered as much as the others; but it just looked different to me. It looked like more of a tan or brown or darker gray.

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IRWIN The color could have been slightly different. The fresh ones were a very light gray. The fresh ones looked like hard, angular, fragmental debris covered on the inside; and this one just didn't look quite so hard. It had a different color. It will be interesting. We sampled both types so we could compare them.

SCOTT We headed on to 9A, which was on the terrace, and made a rather lengthy stop there. We did the photography. In looking at the rille, I can remember seeing, on the upper layer about 10 percent down, exposure of bedrock with internal layering, quite discontinuous and irregular, but all across the same level and with different characteristics within the layering laterally. I took the 500 vertical/horizontal strips and also other targets of opportunity down within the rille. It is unfortunate your camera was not working there because that really slowed us up. We did a comprehensive sample there which I think was the best one of the whole series. That was where we moved the gnomon to get better coverage with the comprehensive; and we each got a big rock .

IRWIN That one went in the B-SLSS bag.

SCOTT We sort of came up a very slight incline to the rille rim. It was not anything I would call a levee. I think we were quite aware of coming to the rille rim when we got there, and

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SCOTT
(CONT'D)

it seemed to me that it was a very slight incline. Then it broke to maybe a 3- to 4-degree slope down towards the rille to the edge where it broke on down to another inflection point, down to 25 degrees into the bottom.

IRWIN

I got the impression that that next break point, from which we were looking down to where the big blocks were, was a very steep break, maybe 60 degrees.

SCOTT

Well within that layer of bedrock. You could look back down the rille towards the south and you could see that we were on a layer of bedrock.

IRWIN

Looking to the south and also to the north, you could see the bedrock slightly above us. Maybe we were on a terraced portion that had slumped down because you could see the top, the level surface, the top of the bed both to the north and to the south.

SCOTT

I am confident that the large rock that we sampled there was bedrock.

IRWIN

Yes, the one with the very large vesicles?

SCOTT

Yes. We chipped off of it and got a couple of frags off the side of that module.

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IRWIN I was hoping that we would get down lower to where it was obviously bedrock — either down lower toward the rille or to the north or south — but we never had the chance.

SCOTT The color looked darker black. Those very large, almost rectangular fractured rocks, as you called them, looked a little bit like columnar jointing. Those big black ones down there were darker black than the ones we sampled.

IRWIN Yes.

SCOTT Then, I guess we got a couple of cores there. Then we proceeded on up the rille rim to get the stereo, the stereo pan, and the 500 mm photos. Did you think of anything else as we went up there?

IRWIN No. The distribution of fragments seemed to be uniform along the edge of the rille. By uniform, I mean about 20 percent.

SCOTT Yes.

IRWIN On the surface.

SCOTT Yes. That is about right. And a variety of sizes from the 1- to 2-inch size up to the large 1-foot to 1 1/2-foot size.

IRWIN The fragment distribution probably was very similar to what we saw at the south side of Dune.

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SCOTT Yes.

IRWIN Those two might relate very closely.

SCOTT You are right. Those big blocks that had the jointing or the linear fractures in them did not have the vesicularity that that big block did in the bottom, south side of Dune Crater. I don't remember seeing the 3-inch large well-defined vesicles, do you?

IRWIN Yes.

SCOTT In those big blocks?

IRWIN Yes.

SCOTT You think so?

IRWIN I documented one.

SCOTT Did you?

IRWIN It had the same size vesicles. The ones off in the distance you mean?

SCOTT Yes. The ones off in the distance.

IRWIN It seemed that there were some large vesicles, but we really were not close around any.

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SCOTT It did not look to me like it had the very large ones that we saw at Dune Crater. It was the same color.

IRWIN You got some 500s that probably took in that field of view.

SCOTT I think so.

It seems to me that we terminated that rather hastily, and it is too bad we could not have gotten a Pluton. I might comment here, in looking at Pluton, that I did notice that the inner walls were covered with some large fragments. These were on the order of probably 2 meters or so. Maybe 5 percent of it was covered somewhat uniformly, and the outer walls did not seem to have any debris at all.

IRWIN You probably saw that best from the SEVA, though.

SCOTT Yes. I could see it fairly well. I did take 500s of it, so we will see if it shows anything.

Then we drove back to the LM, and the NAV system took us right straight back with no problems. Did we do any rock collecting when we got back there?

I guess we got the DPS engine valve back there on the SESC.

I guess we filled all three SESCOs, didn't we?

IRWIN No, I think we had one left.

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SCOTT Did we?

IRWIN Well, I thought we had done that on EVA-2.

SCOTT That finishes EVA-3 as far as the geology goes that I can remember. Do you think of anything else?

IRWIN No, we had, of course, a lot of rocks that are probably not documented too well.

SCOTT Yes, we were running out of time there. Time and camera. Did you get your pans there? You took my camera and got the pans.

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10.9 LM LAUNCH PREPARATION

SCOTT We'll start into launch prep after the jettison of LM equipment. There's really not a lot to say about it, except that it went as per checklist. We skipped a P22 with the command module because we were somewhat behind time there and that didn't seem to be too necessary anyway. With that elimination, we were pretty much right on the time line all the way up to lift-off, and everything went as per schedule. I think we had run this a number of times in the simulator and felt pretty comfortable with it, even though I remember commenting that that was probably the fastest 2 hours we spent in the whole flight. The alinement went well. The stars were good.

IRWIN It was interesting to me that the star angle difference with the gravity vector was somewhat more than it had been with two stars.

SCOTT Same; .03 and .04, something like that.

IRWIN Here it is. Plus 08 here.

SCOTT Oh, yes; the first one was. That was a gravity vector. I'm talking about the star angle difference down here at NOUN 05. It was somewhat larger than two stars. That one surprised me a little bit.

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SCOTT Lift-off. All the checkouts of the systems went very well.
(CONT'D)

We powered up as advertised.

IRWIN We were really pressing now, with not much extra time. We had
a change on angles here for the rendezvous radar that they
voiced up real time.

SCOTT Which didn't help us any, I guess.

IRWIN There's a question there. Why'd they come up with them real
time?

WORDEN I think it was probably because of the orbital changes.

SCOTT Could be. I guess our antenna drifted. We can talk about
that when we get to the ascent portion. The checklist looked
all right. The switch settings all worked. I remember it
being very busy throughout the time line, but we were never
behind. We were just about 5 minutes all the way. We had
time to get everything stowed properly. Then, we got down to
lift-off.

IRWIN I thought the battery management during the surface went just
as planned. I was surprised it worked as smoothly as it did,
because before the flight they said they were going to call me
on real time and tell us when to switch the batteries.

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SCOTT You did that just as per checklist all the way through.

IRWIN Yes, but I usually asked them if they were ready for it. They always said yes, do it per checklist. It worked out real well, real smooth. We checked in with Al two or three times there on the surface.

SCOTT Two times. Once each day. That worked pretty well. It was obvious they were keeping him informed of what we were doing. We knew pretty well what he was doing, so that played pretty well.

IRWIN Did we mention that we ran out of food there in the LM? We could have used a little more food.

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11.0 CSM CIRCUMLUNAR OPERATIONS

WORDEN My impression of the operations of the spacecraft was one of complete confidence in the equipment on board. Things worked very smoothly, and I didn't have to keep an eye on all the gages all the time. There was very little noise on board. The only things I recall hearing are the suit compressors. I ran them most of the time with the three sets of suit hoses out and screens on the return, so the suit compressor noise was there. Also, I could hear a pump operating in the service module, which I assumed was the water glycol pump. Those are about the only two continuous noises that I had during the lunar orbit operations.

The rest of the spacecraft ran just beautifully the whole time. The fuel cells ran without a problem. In fact, everything ran just beautifully, and I really had no concern for the operation of the spacecraft during the lunar orbit operations. The only things that were off-nominal, of course, were the burns — the circularization burn and the plane change burn, where we had the problem with the SPS main A pilot valve circuit breaker. I made both of those burns on a single bank and they were nominal, except for that particular circuit breaker being left out.

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Navigation was about as it was on translunar coast and up to and after that point of the flight. The guidance system was very tight. I never had any problem getting a star pair. Whether I was doing a slow ORB rate maneuver or whether I was inertial. P52s worked very well.

I still had the problem with the sextant. Even on the back side of the double umbra, the sextant was very difficult to use — to identify constellations and to identify the stars. The attenuation in the sextant was really much more than I had anticipated. I could look out a window and see the star field very clearly. In fact, it was much brighter than I expected it to be. There were so many stars in the field of view out the window that, in a way, it was a little difficult to find a constellation and to find the navigation stars. But through the sextant, only the very brightest stars came through. I was able to identify the stars after a while, after I was used to the star pattern, and I did the alinements just about the same place every time.

Even with the light attentuation through the telescope, the guidance system was so tight that every time I did a P52, I could look through the telescope and grossly identify where I was in the sky. Then when I looked in the sextant, there would be a star right in the middle of the sextant every time. It

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maintained its orientation beautifully the whole time. The drift rates were very low.

The only thing, I guess, that I'd want to comment on concerning navigation, and that in regards the Flight Plan, is that, when we did an Option 1 reorientation, for example, to the plane-change attitude, there was no place in the Flight Plan to write the gyro torquing angles for the second P52. Of course, each of these is done with an Option 3 realinement for drift reasons, and those gyro torquing angles are recorded. But then, when you do the Option 1 to go to the new orientation, there's no place in the Flight Plan to record those. I guess there may not be any valid reason to keep those gyro torquing angles. Possibly the ground doesn't need them, but I was in the habit of writing down the gyro torquing angles, and when I got to the Option 1, I did just this. I recorded them in a blank place in the Flight Plan. I feel that we might consider putting those in the Flight Plan, because they are some indication as to how the coarse aline works.

This reminds me that, on each of the reorientations, I used a coarse-aline option in P52, and in each case, the coarse aline was good enough to put the star in the sextant, except for one instance on the way back home when we went to entry orientation. The star was just outside the field of view of the sextant, and

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I had to look for it a little bit. However, the coarse aline worked very well. In almost every case, it put the star within half a degree of the center of the sextant.

Next item is LM acquisition. After the P24, after the circularization maneuver, the next pass over the landing site was a LM acquisition pass. It was made on REV 15, and that all went very well. The pad was sent up, I went to the attitude, and there were no problems with any of that. Everything went nominally. As I came over the landing site, I saw the LM shadow very clearly, and once I had identified the shadow, then I could also see the LM in the sextant. I watched the LM until I was near nadir, until I was almost to TCA, and then I took out the visual map, the 1 to 25 000 scale, in the CSM Lunar Landmark Map Book, and marked the spot where I saw the LM. That was BR .5 and 75.5, in the Lunar Landmark Book. One more comment on the LM acquisition, and, again, it's a comment that's been made before on landmark tracking. Once the LM was spotted, there was no problem at all tracking with the optics. Of course, at this time, I was in a 60-mile circular in ORB rate, and the rates were very low. But even at the low altitudes, there was no trouble tracking any landmark that you selected with the optics, in either ORB rate or inertial hold. The optics were very smooth in tracking and very positive. As long as the trunnion angle is great enough so that you don't go

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through or close to zero trunnion angle, any landmark you pick is fairly easy to track.

The next item is update pad and alinements. I've already covered the alinements. I used the update pads in the Flight Plan almost exclusively. As a matter of fact, the whole lunar operation was oriented toward using just the Flight Plan for all updates and for all information that went back and forth from myself to the ground, and I found that worked very conveniently. I checked things off in the Flight Plan as we went and wrote all of the corrections and changes in the Flight Plan. This meant that I only had one book to go to all the time, and it did work very conveniently for me.

Next item is mass spectrometer deployment. At the first part of the lunar orbit activities, the mass spectrometer was deployed and retracted almost as I had anticipated, knowing the approximate times the boom should take to deploy and retract. Those times came out very close. Only along towards the end of the lunar-orbit activities did I start to see those times varying. In fact, at one point, the mass spectrometer failed to retract. I never did get a gray indication. I turned it off, turned the retract mechanism off, and extended and retracted the mass spectrometer in short bursts, cycling it until I got a gray indication. This meant that the mass spectrometer was

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very close to being fully retracted, but yet something was holding it from the final retraction. Looking in the Flight Plan, I noticed that the first time I saw a problem with the mass spectrometer boom was at approximately 119 hours and 20 minutes in the flight, when I got no retract on the mass spec boom. At that time, I had retracted the boom and waited approximately 2-1/2 minutes and then started watching the talkback, expecting it to go gray so that I could turn the switch off. Instead of going gray, it went to a half barber pole; the gray shutter in the talkback dropped about halfway, and it stayed there. I cycled it to extend three or four times, maybe bursts of 5 or 6 seconds, and then to retract. And after about the third cycle, the talkback went gray, indicating that it had fully retracted.

I ought to clarify the operation of the talkback. On all the extensions, the talkback was full barber pole until the boom was extended, at which time it went gray. On the retraction, it was full barber pole until the nominal time for full retraction had elapsed, at which time the talkback went to half barber pole. That was the only time, on that last bit of the retraction, when there was anything unusual about the operation of the talkback.

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HENIZE Did you ever notice a half barber pole in later retractions?
We never heard anything more about it.

WORDEN Yes. On each succeeding retraction, after that first one, the mass spec boom operated exactly the same way. I always got the half barber pole. After 4 or 5 cycles, for a considerable amount of time at least, I could always get the gray indication. Along towards the end, it finally got to the point where I never could get full retraction on the mass spec boom. In fact, during the EVA, we had cycled the boom to extend and retract on the short cycles several times. I never could get a gray, and when I looked at it during the EVA, the cover was tilted about 30 degrees on the hinge, and the guide pins in the mass spec were just barely coming through the guide slots. It was on the guide rails, but the pins weren't fully extended through the guide slots.

The next item is bistatic radar test. That was all nominal. There were no problems with that. It was a P20 type maneuver, which was conducted during one complete front-side pass; I think two times. That was done all as per Flight Plan with no problems.

Solar corona photos: they were done as per Flight Plan. There were no problems with any of the solar corona passes. Everything worked very well, except that — I should make a

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comment at this point — that the solar corona photography was done using a countdown clock on the DSKY, which I called up by using P30 and loading the T-start time into the computer, in P30, and then letting the computer keep track of the time for me. At this time, there was no lighting in the LEB for the mission event timer, and solar corona photography required that the lights in the spacecraft be turned low. Because of the light problem in the LEB, the rheostats that adjust the integral and numeric slidings were taped in the position that they were in when we had the problem with the AC. This meant that the DSKY in the LEB was at a higher intensity than I would have liked for the solar corona photography. There was considerable light inside the spacecraft as a result of the lighting in the DSKY and the LEB. I turned all of the other lights out and monitored the DSKY in the LEB to do the solar corona photography and all of the other low-light-level photography.

Another comment on the use of P30 for the timing of some of these things in flight, and that is that, after I had used P30 for a while to time the events, I was called by the ground and told not to use P30 so extensively, because I interrupted the integration of the state vector in P20, which meant that the orbital-rate attitude was varying and was actually drifting outside the limits that we required for flight.

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My recommendation is that we somehow devise a way of monitoring time on the DSKY, since it's a very convenient way of doing that particular thing. The digital event timer on the main panel is too far away, and it's unusable for that type of activity. It means that the DSKY is really the simple solution, if we can somehow load the computer to count down to a time and then to count minus time to zero and then count plus time, so that these activities can be monitored.

Next item is the UV photos. I think all of the UV photos went as per Flight Plan and went on schedule. There were no problems with the UV photography. Most of the UV photography was done when all three of us were on board. Jim handled all of that. I read the checklist, and it worked very well.

Window number 5 was covered with a Lexan shield, which acted as an ultraviolet filter for those portions of the flight when we weren't taking ultraviolet pictures out that window. Because of the distortion and the poor optical quality of the Lexan, pictures would have been greatly degraded if they had been taken through the Lexan shield. There were some portions in the Flight Plan where it called for the Lexan shield to be removed for visual or for orbital-science photography, which was not ultraviolet photography. At some portions in the Flight Plan, where some of that photography was being done,

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the Lexan shield was left off the window for periods greater than the time prescribed in the Flight Plan. I observed no effects from any ultraviolet radiation. I don't believe there's anything that was observed after flight either.

The lunar libration photography was performed using the 35-mm camera with the very high speed black and white film. The camera was mounted in window number 4, the right-hand rendezvous window, through a shield that was placed in front of the window to screen any interior lighting from the lens of the camera. I always had to take considerable time and patience to put the lens in the slot in the opening in that filter to make sure that I got a good field of view in the camera. The filter or the shield really didn't seem to fit as well as I thought it should. So it took me a little bit more time to make sure that the shield was around the lens and the lens was in the window properly. Once that was done, I found the 35-mm camera very easy to use, and all of the low-light-level photography was done as per the Flight Plan. We had just the right amount of the film. There was some earthshine also taken with that film, on MAG T, and the other low-light-level photography was done as per Flight Plan with no problem. Once again, I used the DSKY in the lower equipment bay as a clock and turned the other lights in the spacecraft out.

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The orbital science photography, for the most part, went as per the Flight Plan. There were a few instances where some other activities were scheduled real time which interfered with orbital photography, and in those places, the photography was not accomplished. In the Flight Plan, the orbital photography was almost invariably strip photography, with the camera being held in the window and pictures taken at some prescribed interval, such as 15 seconds or 20 seconds. Those at 20 seconds were done with the intervalometer, and those at the other times were done just by counting on the clock.

In almost every case of orbital photography, the ground site had been analyzed preflight, so that I knew what the targets were. In flight, rather than just take pictures looking straight out the window, I concentrated on taking pictures of the sites that we are interested in. That worked in almost every case. There were several strips of photography taken from Crisium to Serenitatis. I think there were five strips scheduled to cover some of the Lunar Orbiter photos that were of very poor quality. We got all of those, except one strip, which was replaced real time by some other activity. I don't see it in the flight right now, but, as I recall, there was one strip that we didn't get. The rest of the orbital photography all went pretty much as planned. I had no difficulties. The targets of opportunity, I found fairly easy to handle, as

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far as the camera settings were concerned. The camera settings were both on the Fullerton wheel and on the lunar orbit monitor charts. I found that all very — fairly straightforward and easy to accomplish.

Monitoring lunar activity: There was ample opportunity for me to observe the lunar surface from the spacecraft. There were some periods specifically set aside to do nothing but that. During periods of SIM bay operation, I had ample opportunity to look at the surface. I found no problems with that.

Next is SIM bay daily operations. I want to talk first about the Flight Plan. I found that the Flight Plan for the solo portion of the operation in lunar orbit worked quite well. I think that the only reason that it worked well is because there were very few updates to the Flight Plan during that period of time. The SIM bay operation is a monitoring operation as much as anything else. It got to be rather difficult at times to keep track of the times and to do things at the times prescribed in the Flight Plan. To do that meant that full attention had to be devoted to just keeping track of the time and switching the instruments on and off at the proper times. One thing that was used in flight was that the ground would give me a 30-second or a 1-minute warning on when to do some particular switching, and that seemed to work quite well, because, as I was off doing

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something else, doing a visual sighting or operating something else in the spacecraft, the 30-second warning gave me ample time to get to the SIM bay station and accomplish the things that had to be done. I found that a great deal of my time was spent in monitoring the SIM bay operation, in getting all of the experiments running, in deploying and retracting booms and the mapping camera.

Essentially, the basic instruments in the SIM bay were started in the morning after first getting up. They operated rather independently all day long, except for some changes in the gamma ray and some changes in the mass spectrometer, in the gains and that sort of thing. Most of the time in the SIM bay was devoted to operating the cameras, and that's where the clock watching was most important. The SIM bay operation is a very complicated operation. We attempted to simplify it with the Flight Plan that we used. The plan was to use the checklist as an operational guide and to use the Flight Plan only as an event guide. This meant that, when the event was about to occur, you go to the systems checklist and perform that particular function, such as extending the boom and operating the experiment. I found it rather unwieldy to do. It left you with a feeling that you weren't really aware of what that instrument was doing with respect to the rest of the SIM bay.

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Each operation was an individual operation, and a lot of the SIM bay activity had to be done roughly at the same time.

For my own use, an integrated flight plan or an integrated switch list, such as we had in the Flight Plan, was most efficient for me to use when I was by myself. We did have some real-time updating during flight when there were three of us inside the spacecraft. We did use the checklist for some of those portions of the operation. Those operations worked about as well as the operations where we used nothing but the Flight Plan. It's a personal preference on my part that everything appear in the Flight Plan. It does pose problems if you have a lot of real-time changes, because it takes a great deal of time to write the changes down in the Flight Plan.

I found that my biggest single problem with the operation of the SIM bay was in not being continuously aware of the state of the various experiments in the SIM bay. The only indicators on board are the talkbacks associated with each of the instruments. In both the stowed position and the operate position, those talkbacks are always gray. You really have no way on board of identifying the mode of operation of each of the instruments without going back and referring to the Flight Plan and knowing that you've performed the functions on the Flight Plan as prescribed. This caused some confusion at times when

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we had real-time updating, because then, the SIM bay got in a nonstandard configuration with respect to the Flight Plan. It was very difficult, without a lot of discussion from the ground, to determine the mode of each of the instruments and what had to be done at the next step. It would be a great help if there were some indication on board of the mode that each instrument was in at the time.

A comment about the solo portion of the Flight Plan, with respect to the amount of activity involved. That portion of the Flight Plan was not too crowded. Outside of monitoring the spacecraft and doing the visual sitings, my main function was to monitor the SIM bay. I found that that all worked out okay and that there was no undue amount of work associated with it. It was just time consuming, and so much of the operation involved sequential switching and monitoring of the clock. As far as the time was concerned — the work load was concerned — I found it not to be excessive.

A comment on the Flight Plan, in general. Something that should be factored in carefully into the Flight Plan, particularly during the solo portion, is the fact that it takes longer to do things in flight than you'd anticipate. For instance, to eat a meal seems to take me considerably longer than I had thought would be required before flight. Invariably, there

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were things to do right in the middle of an eat period which took your attention away from that part of the flight and extended the eat period considerably from that shown in the Flight Plan. The same thing was true of the exercise periods. I tried to get the exercise during those periods when it was called out in the Flight Plan, but again, there were things that had to be done almost inevitably during the exercise periods. Every effort should be made in keeping those periods free from any other activity, and sufficient time should be allowed for those things in flight, so that you can get them done, get them out of the way, and get the spacecraft cleaned up again before you get back into the working part of the Flight Plan. That would pay great dividends in the orderliness with which the SIM bay operation is conducted, not having to intersperse that operation with the general housekeeping operations that have to be done on board.

Let me now talk about the individual experiments. Most of the experiments operated just as we had planned preflight, and there's nothing to say about them. The mapping camera works just as I had expected it to work. I kept track of the extend and retract times, and everything was nominal until the very end of the flight, when the mapping camera failed to retract. It just stopped, and it looked to me during the EVA that it was fully extended. I looked around to see if there was anything

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that had jammed it or anything that could have interfered with the mapping camera to cause it to stay extended, such as the covers being jammed against the side of the mapping camera. I could find no evidence of any of that happening, any jamming at all from an external source causing the mapping camera to fail to retract.

The X-ray, laser altimeter, gamma ray, and alpha particle experiments all worked as per the Flight Plan. The laser altimeter apparently was failing somewhat in flight, but it didn't affect the Flight Plan and didn't change the Flight Plan, except for a few real-time changes, as concerned the laser altimeter itself.

The mass spectrometer was the most troublesome, in a way. The experiment itself apparently worked well, but the boom failed to retract properly. That started almost from the very beginning of the lunar orbit operations, in that the mass spectrometer would not retract properly. I think I've already covered that previously.

The gegenschein calibration photos went as planned, and as I commented before, the lights inside the spacecraft were primarily from the lower equipment bay. There was some afterglow in the floodlights, and I taped the floodlight above the right-hand rendezvous window to reduce the light from that source.

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The zodiacal light and the gegenschein were about the same, in that the experiments went as we programmed them preflight. They went as scheduled with no problems.

General photography within the spacecraft: I had inserted in the Flight Plan at the beginning of each day's activity those magazines that would be required for that day's activities. That worked very well in helping me organize the photography for the day. I used one of the fabric containers just to the left of the side hatch as a storage bin for the magazines and for the cameras when I wasn't actually using them. That worked very well, because, with the center couch out, I was standing in a position which was very accessible to that particular compartment and to window 5 and window 4 and to the side hatch for taking the pictures. It was very convenient and worked very well.

The plane change was a nominal burn, except for the single-bank portion of the burn, this being an off-nominal condition. The plane change went as planned. Realignment was very simple and worked very well. There were no problems associated with it. Residuals on that burn were 2/10 ft/sec, which was the trim lower limit. So that burn was not trimmed.

A comment on the plane change, and it applies to other maneuvers that have to be done, particularly solo. Sufficient time should

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be allowed before those maneuvers to get the SIM bay operation cleaned up and ready for an SPS maneuver. I didn't notice any particular bind in the timing of getting the SIM bay powered down for the plane change. Of course, the SIM bay wasn't in operation for the circularization burn. For the plane change, I powered down the SIM bay approximately 15 minutes before the burn. If at all possible, that time probably should be extended a little longer before the burn just to allow time for any anomalies that might arise before the plane-change burn. Although, in this case, I had no problems. I do recall thinking at the time that it would have been nice to have had a little more time there.

Communications during lunar orbit operations were very good. I don't recall having any problem getting the high gain locked up at the times prescribed and that whole operation went very smoothly. I manually switched the DSE after LOS and I don't recall any case where the tape recorder wasn't already operating the way it should be; the way we had expected it on ground command. So, that was merely a manual backup to a switching action which had already been performed.

The rendezvous portion is next; maneuvering support lift-off. We did the vhf check. That went well. Prior to the rendezvous, I was asked to do a P24 on the LM for the rendezvous

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targeting. This was the result of an insufficient time line in the LM to allow them to do a P20 or a P22. I did the LM visual at about 170 hours and was never able to identify the LM on the surface. Two things I think caused that particular result. One was that the Sun angle was very high and that there was no discernable shadow from the LM, which helped me on the first LM visual to recognize and locate the LM. The second was because of the Sun angle, or at least I assume it was because of the Sun angle, the landmark line-of-sight part of the optics cast a very red or bright pinkish to red image in the sextant, which was very difficult to see through to actually look at the terrain. The landmark image kept sweeping through the sextant as I was looking at the landing site in the sextant. It was so bright at times that I couldn't see the actual image of the terrain. That also added somewhat to the confusion. Maybe that can be explained in terms of the geometry of the optics and the particular Sun angle at the time. I wasn't able to pick up the LM and I don't feel that that was a very successful landmark tracking pass.

The rendezvous was as nominal as any rendezvous we ran in simulations. We did have some communications problems on the rev prior to rendezvous so that the rendezvous pads were read to me by the ground at AOS on the rendezvous rev. That all went very smoothly with no problems. We did the vhf check and that

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worked okay. I did notice after lift-off that it took several attempts to get the vhf ranging reset so that it would stay locked up. Once I got it locked up, it was about 136 miles. It stayed locked up from then on. I think it broke lock only once and I got the tracker light. From the LEB, all I could see was a caution and warning light, a PGNS light. When I checked the DSKY on the main panel I determined that the tracker light was on and then I knew, of course, that the vhf had broken lock. So, I reset it and everything was fine.

I got the state vector of the LM and started looking for the LM, but I couldn't find it. The LM was not in the sextant when I started looking. I went to the telescope and could not see the LM. I called in to make sure that the rendezvous light was on; that the beacon light was on and it was. About that time I picked up a very faint flash in the telescope, about 10 degrees away from the center of the telescope, and I slewed the sextant over to that point and picked up the LM. The tracking from there on went very nominally and, in fact, ended up prior to TPI with 19 vhf and 18 sextant marks. The solutions were very close on the recycle; the X and Y solutions were very close, and in the Z solution I had about a 4- or 5-ft/sec difference from the LM. On the final comp, the Z solution was within 1.6 ft/sec and X and Y were within a

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few tenths of a foot-per-second difference. Rendezvous was very nominal and, as I said before, was one of the most nominal that we've ever conducted.

I backed up the TPI burn by maneuvering to attitude and following the cue card for backup burns. I got all the systems on line, except that I did not turn on the EMS and I did not turn on the DELTA-V thrust normal switches. I let it count down to zero at which time the LM did the burn and nulled out the residuals. I went on into P76 and on into P35. The MINKEY program worked without a flaw during the whole rendezvous. I never had a problem with it. It sequenced automatically and everything worked just as planned. During the first midcourse correction, I had 11 vhf marks and 18 sextant marks and the solutions from the CMC and the LM had maybe 1-1/2 to 2 ft/sec difference. The LM executed the maneuver on their solution. The TPF phase of the rendezvous was nominal. The LM came to within about a hundred feet of the command module and started stationkeeping. I then did a VERB 49 maneuver so that some SIM bay photography could be accomplished and went back to the docking attitude. After that the docking was nominally completed. There were no problems with any of the docking. The predocking checklist was carried out as listed and I thought that the whole thing went very smoothly.

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12.0 LIFT-OFF, RENDEZVOUS, AND DOCKING

SCOTT The LM lift-off preps down to T-0 were nominal. The ignition occurred automatically. The pitchover of the LM was very smooth. The spacecraft seem to be more stable than we'd seen in the simulator. The oscillations due to the PGNS fuel saving program were somewhat less than I had expected. Everything went smoothly and very slow. We had a great view of the rille as we went across. I thought the ascent was pretty nominal all the way up. Do you remember the numbers?

IRWIN They were very close to chart values.

SCOTT I don't remember anything that led us to suspect a problem during the ascent. When we attempted to get lockon with the radar — we had previously been given different numbers for setting the antenna — I pushed the circuit breaker in about 4-1/2 minutes and didn't get a lock. I waited until about 5-1/2 minutes and still had no indication of signal strength on the AGC. I slewed it up, down, left, and right in high for about 5 seconds in each direction. I received no response on the AGC. I don't have an explanation for that.

WORDEN I confirm that. On board the command module there was no indication of the systems test meter that you'd locked on.

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SCOTT We either had an antenna drift or the numbers they gave us were incorrect. I would suspect the antenna drifted like it did on Apollo 14, which it wasn't supposed to do.

Just prior to insertion we received a call to trim the AGS rather than the PGNS. This was somewhat of a surprise, as we had no indication up to that point that there was anything wrong with the PGNS. You closed the interconnects at 500 and that worked as advertised. Everything was nominal with 200 ft/sec to go. After automatic shutdown, we attempted to trim the AGS. I couldn't get the X-axis less than 2 ft/sec, because it kept building. That was not unlike what we'd seen in the simulator on previous rendezvous. We did ask at some point what caused that and I don't ever remember getting an answer. It seem like the AGS continued to build like it was still calculating and still projecting the orbit to the insertion parameter. We terminated trimming AGS at about 2 ft/sec, trimmed Y and Z, and informed the ground. Shortly thereafter they came up with a no-tweak call. It was pretty quick. We confirmed comm with the command module before lift-off. Ground had their hand over and that was something like 2 minutes before lift-off. This was a little later than we'd been used to in the simulations, and I think that was because the mountains blocked the VHF.

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WORDEN Yes. I could hear you sporadically until just prior to lift-off, then you came in loud and clear. I could hear portions of conversations up to that point, but it would keep breaking up.

SCOTT I think that was due to the mountains. We had PIPA bias to load before lift off, and I had some additional PIPA bias coming into TPI. I guess we must have had a bad PIPA all the way.

Let's go ahead through the rendezvous navigation. We did the automatic P20 to the track and the attitude and I got a visual on the command module with the COAS. The radar needles were aligned, the PGNS needles were a little off, and the AGS needles were fairly well aligned. The AGS really had a better vector than the PGNS at that time. So with confirmation of good angular data, we began to update the PGNS and the AGS automatically. The PGNS had one NOUN 49 on the first mark. It was a small one and I incorporated it. Then, we proceeded to take marks automatically right up to the first recycle point. We cleaned up the cockpit as per checklist, and everything seemed nominal at that point. Can you remember anything up to the first recycle, Jim?

IRWIN Just that the AGS warning light came on and we've already talked about that.

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WORDEN I waited until I got a state vector from the ground, and the first thing I tried to do was get the VHF locked up, but it wouldn't lock up. I guess I reset the VHF range four times before it finally locked up. The first good solid range I received was at 136 miles. That was a closer range than what we normally saw in the simulators. I guess it was because of the orbit that I was in at the time.

SCOTT They told us — I'm not sure they told you — that we were going to have an off-nominal trajectory. Did you know that?

WORDEN I recall them saying that the rendezvous was going to be off nominal because of the orbit that I was in. I was expecting something a little bit different. When you called and confirmed the 136 miles, I believed the VHF and started taking marks.

SCOTT You locked up before we got insertion. On the way up, in spite of the fact that we had no radar, you gave us the VHF range, we checked the PGNS and the AGS, and they all agreed.

WORDEN That's right.

SCOTT They all agreed, so we got that confirmation before insertion.

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WORDEN That was just before insertion. It was a little later than we'd seen in simulations.

SCOTT I kept trying to get the radar locked up. Did you proceed on your tracking schedule as planned, Al?

WORDEN I did. I received the state vector and went into MIN Key, called up P34, and loaded the TPI time. Then, I let the CSM do an automatic maneuver back to the tracking attitude. I looked into the sextant and I didn't see anything. I looked into the telescope and I didn't see anything, but there was still some sunlight shafting into the telescope. It was still pretty bright out there, so I couldn't see anything. When we finally got into darkness, I'd estimate 12 to 15 degrees from the center of the telescope, I picked up a flash out of the corner of my eye. I manually drove the telescope over to that point and picked you up in the sextant. You came in loud and clear in the sextant. The light was really bright. I asked you about your tracking light about that time and you said that you had it turned on and you could see it flashing. You could tell that it was on.

SCOTT That is one of the things you can see from the left window. You can see the light flashing on the hand rests. Jim couldn't

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SCOTT (CONT'D) see it on the right side because there was nothing for it to reflect on, but you can definitely tell the light is working on the left. That means you didn't see us until we got into darkness.

WORDEN That's right. I didn't see you until you got into darkness. I had two large NOUN 49s and after that everything was right down the line. I had 18 optics marks and 19 VHF marks until TPI.

SCOTT Let's discuss the recycle first. How many marks did you have when you went through the recycle?

WORDEN I had seven marks when we did the recycle.

SCOTT Seven of each?

WORDEN I had nine VHF's and seven optics. In simulations, I always did the recycle when I got seven optics marks and accept whatever VHF marks I have at the time.

SCOTT We did a recycle when we had 15 marks. There had been some discussion prior to the flight on the comparative values at the recycle point. We have the ground solution, the PGNS, the AGS, and your solution for TPI. Jim, why don't you give them

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SCOTT (CONT'D) for reference. I think we expected to see a fair disparity in the Z-axis and we did. This confirmed the preflight data.

IRWIN Do you want me to read them into the tape?

SCOTT Yes.

IRWIN The PGNS final was plus 70.3 plus 5.9 and minus 17.7.

WORDEN Jim, give the recycle first.

IRWIN Okay. PGNS on the recycle was plus 70.6, plus 5.9, and minus 16.9. CMC on the recycle was minus 69.4, minus 6.2, and plus 12.0. The AGS solution that I have written down was the solution right at insertion; it was plus 67.5, minus 6.4, and minus 30.4.

SCOTT Did you have one at that recycle point?

IRWIN I didn't write it down for that point.

SCOTT How about that ground solution? What was the first one that they gave us?

IRWIN The ground solution was plus 66.3, plus 7.8, and minus 31.2.

SCOTT The reason I wanted to put that in there is we're the only ones that have some of these solutions. So at least the trends

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from all of these were the same. We knew at preflight that we were going to be within three sigma. It was comforting, because there were some pretty big deltas. The ground had told us that our TPI would be somewhat different from the nominal, even to the extent that we wouldn't have to pitch all the way around. We would not have to do the YAW-ROLL maneuver but we would break radar lock. I think their first cut on their solution was a little off, because their subsequent TPI and ours led us into an almost nominal TPI. We could see this trend coming as we were doing everything nominal, just as planned.

IRWIN

The recycle gave me a warm feeling. We knew beforehand that we would see some differences in the Z-axis, but I think it gave me a good feeling that the X and Y components were almost nominal. I felt we had good solutions going then.

SCOTT

After the recycle, we continued to take automatic updates. Could you see us all the way in from there?

WORDEN

Yes. Once I picked you up and had you in the sextant, I never lost you again.

SCOTT

As soon as you went into darkness, I lost you visually. I had a very small reflected image on the order of a second magnitude star before we went into darkness. As soon as you went into

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SCOTT (CONT'D) darkness, I lost you. I know your light was on because I saw it again at about 18 miles. All the way into TPI, I had no visual. I was glad we had confirmed the radar and the PGNS before we got into darkness because your light did not give us much. Did you add any manual updates to the AGS, Jim?

IRWIN Not until the end of TPI.

SCOTT It was all automatic into TPI. We got down to the final count point, and you gave us a call, Al, on your final comm point; and we proceeded after 26 marks, which was about 9 minutes. If we had one more mark, we would have passed 8 minutes. We came up with everybody's final solution, and that is one I know the ground does not have. Why don't you read those, Jim?

IRWIN Final solution for TPI. PGNS was plus 70.3, plus 5.9, and minus 17.7. The AGS was plus 70.4, plus 5.9, and minus 19.1. The CMC was minus 69.1, minus 6.1, plus 16.1. Dave, these are negative values for Z, and nominal was plus; so we knew the Z values were still quite a way off from nominal.

SCOTT Did the ground give us a second solution?

IRWIN Yes, they changed the Z to a minus 19.0, which is what the AGS came up with.

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SCOTT This pulled everything together, and I think our only difference was in Z. That was much, much less than the acceptable deltas in the burn rules, so we accepted the PGNS solution and passed it to Al. We then proceeded into the nominal procedures for the burn. We made a 3-second automatic burn using the APS. We had the prescribed 10-second ullage, and everything went nominally. We had an overburn of 4.3 ft/sec. We had somewhat of an overburn in Z, too.

We did have to trim out X for about 4 ft/sec and a little bit out of Z. You had plus 0.2, plus 0.2, and a minus 0.4 when we finished trimming. At that point, we proceeded to go into P35 and passed the data down. We started the burn and began taking marks again. Did you have any trouble picking us up after the burn after you had loaded your P76?

WORDEN No, I did not have any trouble picking you up. We were close enough then so that there was no problem seeing the light in the telescope. You were out of the sextant field of view on the first marks that I took, and so I had to go to the telescope. There was no problem at that point. The range was close enough so that I could see the light without any problem.

SCOTT Here are the pretrim residuals on TPI, minus 4.6, some small number out of plane which I did not write down, and a minus 4.2. That is pretrim and that put us in a 64.2 by 38.2 orbit.

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SCOTT
(CONT'D) We proceeded into the solution for midcourse 2. We got a few marks to get the tracking going, and I rolled back around to a heads up. Did you go automatic all the way or did you add some manual marks in there?

IRWIN That was a combination. I went automatic for range, and manual for range rate to make sure I had enough. And the PGNS, of course, went automatic. I guess you got your prescribed number of marks.

WORDEN The program MCC-1 had nine VHF and 10 optics marks.

SCOTT I think we had eight in the PGNS, or something like that.

IRWIN In AGS, we had eight and seven.

SCOTT Okay, that would add up. At 12 minutes after TPI, we all proceeded and I gave Allen the call. He asked for a call in the PRO and the final comm so we would be synched. We were 3 seconds difference in time break which I think is exactly right because we got a 3-second burn and we came up with the first midcourse solution. Do you want me to read those off?

IRWIN Yes.

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SCOTT PGNS minus 1.1, 0, and minus 1.1; CSM plus 1.5, minus .2, plus 1.9; and AGS minus 1.5, 0, and minus 3.0. At that point, it looked like the CSM and the AGS were both trending towards a higher midcourse than the PGNS; but since we were on the PGNS and it was apparently running all right, we accepted the PGNS solution and burned it. Now, did we get a PIPA bias update prior to TPI?

IRWIN Apparently, we did. I wrote it down right here. 14/52 and a 14/56 which looked like we had some sort of PIPA problem still with the PGNS. It was not a problem, but with the bias changing like that, there was something different.

SCOTT We burned the PGNS solution and pressed on into midcourse 2. I might add that the first time I saw the command module was prior to midcourse 1 at about 18 miles, and I could see the CSM light very dimly. I guess we all proceeded for final comp at the same time for midcourse 2. Do you want to read those numbers, Jim? They were a little bit larger, indicating that we might have had a better solution had we burned the CSM or AGS at midcourse 1. This sort of indicates the PGNS was a little behind on the solution.

IRWIN Solutions midcourse 2: PGNS minus 0.8, plus 0.6, minus 2.6; CSM plus 2.8, minus 0.3, plus 6.2; AGS minus 1.4, plus 0.3, and minus 4.1.

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SCOTT Al, did you get a previous set of marks between MCC-1 and 2?

WORDEN Yes, in fact the best set of marks I had probably was between midcourse 1 and midcourse 2. I had 11 VHF and 18 optics marks.

SCOTT Wow! That's good. I have 10, I think, on the PGNS and Jim had —

IRWIN Coming in to midcourse 2, I had seven and seven.

SCOTT Did you do manual there, too? That sort of says that PGNS is in the ball park, and they are all generally in the same direction and have the same trends; but the PGNS is not giving quite as heavy a solution from midcourse 2 as the other two. Nevertheless, we were within the bounds and we burned the PGNS and proceeded on into TPF. I guess you could see us all right after we popped into daylight.

WORDEN Yes, after MCC 2 and we got back into daylight, I tracked you in the sextant visually the whole way.

SCOTT Then you must have seen us in daylight prior to midcourse 2?

WORDEN Yes.

SCOTT We saw you in the daylight all the way in. The ground told us that we would probably approach somewhat off nominal and that

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SCOTT
(CONT'D)

we would be almost horizontal during TPF, which we were. As we approached the braking, we came through the first gate at about 25 ft/sec, and our final solution in PGNS had given us a TPF of 25 ft/sec; so that ought to match very well. There was no braking at the 6000-foot mark. At the 3000-foot mark, I braked down to 20 ft/sec. At 1500 feet, as I was coming back to 10 ft/sec, I noticed I had a visual line of sight rate up and left. The radar needles were not giving me any indication; so I checked to make sure we were on low mode on the needles, and we were. If anything, the vertical needle was displaced just a little bit to the right.

I could see by our attitude in the ball that we were coming in out of plane. We had some out-of-plane correction at the beginning of the TPI. What was surprising was that I had to start making corrections up and left in a tight deadband attitude hold to keep the COAS on the command module. The radar needles were not giving me any indication of out-of-plane rates — line-of-sight rates. I guess I don't understand that one right now. I do not know why we are getting that, but to maintain the CM fixed inertially, I gave a fair amount of up and left thrusting as we came into the braking attitude. I came into the final stationkeeping position. When we got to

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SCOTT (CONT'D) stationkeeping, did you have anything on the braking? I guess that was sort of a nominal thing.

WORDEN Well, that was all pretty nominal. The only thing I recall was that, starting at about TPF, I went to attitude hold to watch the line-of-sight rates. As far as I was concerned, you had a rate slightly up, with respect to what I was seeing.

SCOTT Yes, you could see some line-of-sight rates.

WORDEN In fact, you ended up a little high on me when we finally got into docking, and I had to do a pitch maneuver. I do not recall now how far it was, but it was maybe 5 degrees to get the COAS back on the line of sight. You were a little bit high with respect to my attitude hold at the time.

SCOTT Your attitude hold and our attitude hold ought to be showing our line-of-sight rates if they are holding right. We ended up out of plane in attitude. We were about 20 degrees off the proper axis attitude when we got on station.

You maneuvered to the SIM bay attitude, and the ground called us to take a look at the V/H sensor on the pan camera and to take some pictures. I thought your maneuver worked out very well. We put ourselves in a tight deadband attitude hold and just watched you maneuver around and we ended up looking right

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SCOTT (CONT'D) at the SIM bay. We took a look, and I could not see anything wrong with you V/H sensor, although I have to admit neither Jim nor I knew exactly what to look for. It was there and wasn't obscured. The next little funny occurred when you maneuvered back to your original attitude, which I assume you did.

WORDEN No, that is where the confusion existed in that attitude. When we were at the first stationkeeping attitude, I did not check that against the Flight Plan to make sure the gimbal angles were all the same. I did the pitch-around maneuver for SIM bay photography per Flight Plan and just put the numbers in from the Flight Plan. Then when I did the maneuver back, I went back into the Flight Plan attitude and that is where the difference in that position was.

SCOTT I could not figure that one out because we ended up pointing at you eyeball to eyeball and did a maneuver over and a maneuver back and we were not pointing at you any more.

WORDEN That is right.

SCOTT That is because you went back to a different attitude. You started from TPF attitude and you went back to the Flight Plan attitude.

WORDEN Right.

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SCOTT That was no problem because we just maneuvered around there facing you and then we set ourselves up for the docking by the checklist procedure. We pitched down and yawed left, and it looked to me like that put you in a good position for the docking. I could see out the overhead window, and it all seemed to line up. Why don't you go through the docking part?

WORDEN Docking, except for one thing, I guess, was completely nominal all the way down the line. I went right through the predocking checklist, and you got lined up. I got lined up on target and closed on you. I think maybe the closing rate was a little bit low. I think it would have been better if I had had a little faster closing rate. I guess maybe I was about 0.1 ft/sec when I came in — maybe even a little less than that. There was no problem with the control. I felt it was pretty smooth all the way in; but when we made first contact, the probe did not slide right in the drogue as I had sort of expected it would, so I thrust a little bit more after contact before we finally got it all the way. That is a note to make. While docking with a light ascent stage like that, the closing rate really should be a littler higher; and it probably would work better if it were a little higher.

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SCOTT I could see out of the top window, and it looked to me like you were coming very slowly. You got the barber poles and pulled us in, and there was no question when we got hard dock. I turned off the mode control switches. You took over the attitude holding and we proceeded to do the power down and transfer stuff.

We plotted ourselves on the relative motion plot several times. During the post TPI period, we were somewhat low and forward. We might have expected that because of their call we would end up roughly in a horizontal plane at TPF.

IRWIN Yes, we did get a call that we could not use the chart solution for TPI.

SCOTT That is because we were that far off nominal, so we did not even check it. Oh yes, and another thing. When we went to TPI attitude (even though we were still well within radar coverage when we maneuvered to the attitude) at the completion of the maneuver when the spacecraft stopped and went into the attitude hold, the radar broke off just from the impulse of the stop in the attitude hold. That surprised me. It stayed off until we reselected P35 after the TPI maneuver. I was surprised to see it break off just with that little jar.

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13.0 LUNAR MODULE JETTISON THROUGH TET

WORDEN The postdocking sequence went very smoothly. We had no problems getting the stuff transferred back and forth. Right after docking when we were trying to transfer some of this stuff, we were faced with a SIM experiment prep cue card and a lot of SIM bay activity. It really confused things because I was trying to do the SIM bay operation and you were trying to talk to me through the tunnel. Our coordination, I thought, was hampered quite a bit by the fact that the SIM bay was being fired up at the time. That is at least one point in the Flight Plan where maybe we should not be fooling with the SIM bay. It is the same as before PDI when we finally eliminated the SIM bay activity because there were too many other things going on.

SCOTT Actually, that is an absolute requirement because when we got docked with you, we were depending on you to take care of all that stuff. Everytime I looked in the tunnel, you were down in the LEB or somewhere doing SIM bay stuff. I kept having to say, "Hey, Al, how about a hand?" I think that really compromised the operations. Even though we had an extra rev to get transferred, we had more gear to transfer and one less man to really help us do it. In the future, you ought to take that period of time and just terminate everything to get all

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SCOTT (CONT'D) that stuff transferred, because with all those rocks and everything, that is a pretty good job.

WORDEN I don't think we had any extra time, even though we had more time in the Flight Plan before LM jettison. I don't think we had any extra time.

IRWIN No, I think it would have been much better if we had had about 3 revs. We could have done it comfortably and checked everything out.

SCOTT Or if we had had Al free. You would have helped. You were loading in the LM, but I was going up into the tunnel; and everytime I went into the command module, he was down fiddling with the SIM bay.

WORDEN It was confusing in the command module because you have a probe and a drogue all floating around in the command module, you are trying to transfer equipment back and forth, and you're trying to do a SIM bay operation at the same time. It is just too darn much.

SCOTT Yes, and we had to get everything configured for the burn, too. The next interesting point was when we got ready to jettison the LM. This is where we ran into a little confusion, so I wrote down that night what we had seen. I would like to do a

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SCOTT
(CONT'D)

quick summary of what I wrote down. We ran the hatch check as per the checklist. I was doing some stowage in the command module, and the DELTA-P when we finished with the hatch was about 3.5. We left it for a while and went over to configure for the pressure integrity check. About that time, the ground wanted to know the DELTA-P. I checked the IM/CM DELTA-P, and it was 2. I called and asked them if that wasn't a little low. They said they thought it was a little low and that they wanted more than that. Somehow, we got some oxygen in the tunnel. The first thought Jim had was that the IM dump valve was open and we were dumping oxygen into the tunnel. We checked the ground, and they confirmed that the IM pressure — I really don't know how we got that extra pressure — did not indicate any leak in the tunnel. We went back and checked the seals on both hatches, which we should have done earlier. I think we waited too long to do this because it was a simple thing to do. With two of us in the tunnel, it was easy. We pulled both hatches out, and I ran my hands around both seals. I felt nothing, but had there been something in one of the seals, it could have blown out or drifted out when the hatch was opened. Al, you looked at the command module hatch seal.

WORDEN

We pulled the hatch down into the center couch, and Jim and I both went over the seals on that hatch as carefully as we

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WORDEN could. We found only one very, very minute nick in the rubber-
(CONT'D) ized seal portion of it.

IRWIN I think that was a manufacturing bubble.

WORDEN It wasn't even a nick in the seal, and we could not find anything on the hatch at all.

SCOTT We put the hatch back in. I might add at this point that we were trying to go very slowly and very carefully, because we knew that everybody on the ground was tired. We were tired, and we wanted to make sure everything was done exactly right. We did not want to blow it at this time. In the process of getting the pressure integrity check on the suits the first time around, we could not get the suit pressure above 6. We had a leak somewhere, and I guess Jim called it. The first idea he had was the LCG connector. Before that, we all checked our helmets and gloves, and everything looked good. The first thought was to put one of those LCG plugs in the suit — the interior, inside plug. Jim undid my suit, reached in, disconnected the LCG, and put the little plug in. You did verify that the LCG was locked.

IRWIN Yes, it was locked.

SCOTT You put the plug in and locked it. During this process, everybody took their helmets and gloves off. We figured it was going

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SCOTT
(CONT'D)

to take us a while. I guess we thought we were going to have to unsuit. We all suited up again to try the integrity check, and it worked fine. So whether it was somebody's glove or helmet or the LCG I don't really know. We were a little surprised that it might have been the LCG. That was the only thing we could think of at the time that was not firmly attached. Everybody checked their connectors and plugs. I might add that my restraints were pretty dingy at that time. We all had dirt on those things. They were getting a little tough to work. That was prior to the hatch operation. After the hatch operation, we ran another pressure integrity check on our suits. We had good flow for about 5 seconds — less than 1 psi. Then it came down to about 6 or 7. That took about 5 seconds. The ground called and said, "You have a good pressure integrity check. Press on." Then the pressure went back up to 1 psi which violated our onboard 15-seconds requirement. We decided that was not a good pressure integrity check, rechecked all the helmets and gloves, and found one glove unlocked. We locked the glove and ran a fourth pressure integrity check. That one worked just fine. We finally reached the point where everybody was satisfied with the hatch seals and the suit integrity. The jettison went with a bang and worked as advertised. You could see the LM drifting out your window. Did you ever run the SEP burn in the simulator?

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WORDEN Yes, I did the SEP burn in the simulator per the Flight Plan. We did that the last day. If we had been at the right attitudes, it would have worked the same in flight. By the time we did the jettison, we were in a different place, and there was some confusion about which direction to make the SEP burn. We needed to get some words on that, because I was confused then as to which direction to go.

SCOTT Yes, the thing that was somewhat confusing was that the LM was right straight out the front window, and part of the burn was directly toward the LM. There again, we thought, let's be careful and not blow it here at the last minute. It did not look too good. I guess that is why we got into the confusion factor. Our concern was to be sure that we made a good SEP maneuver.

WORDEN I recall getting a call from the ground, saying burn the numbers as the SEP pad called. When we were at that attitude and we called up P41 to do that, in body axis, that turns into a burn which was directly at and above the LM. That's when we decided that we had best get this straightened out.

SCOTT I guess we could have made that one, and you could have made sure that we did not hit by deftly maneuvering around the LM. It just didn't look right. Subsequently the ground figured it all out, and we got a 2 foot per second retro, which was

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SCOTT a nice burn. It gave us a warm feeling, and then we all went
(CONT'D) to bed.

WORDEN I thought the second call was a little bit confusing, too.

The second call we received from the ground said, "We want
you to burn retrograde behind the LM. Get behind the LM and
burn retrograde trailing." We were way out in front of the
LM at the time, and it would really have been a major maneuver
to get around behind the LM at that point. So, there was some
confusion by the ground as to what our positions were in the
orbit at that time.

SCOTT You could see the LM for quite a while afterwards.

WORDEN I watched the LM until we got busy doing other things.

SCOTT The vacuum cleaner worked pretty good I thought. We brought
the vacuum cleaner over to the LM and just turned it on and
let it run. It did a pretty good job of clearing the dust
out. We were pretty dirty.

WORDEN The vacuum cleaner is a big bulky piece of gear, we were all
surprised at how effective it was in flight. It really worked
out well.

SCOTT I thought it did, too. We stowed the CDR and LMP suits in
the L-shaped bag, to get the dirt out of the cabin.

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SCOTT
(CONT'D) We left Al's suit out because of the bulk. Al's suit was still clean. We put the filter on the cabin fans and turned the cabin fans on. We already talked about the foreign object in the cabin fan which we heard periodically. When the cabin fan was running with that filter, I thought it did an excellent job of cleaning the cabin. You could sure see the particulate matter floating around there after we finished with the transfer.

WORDEN When we got up the next morning, the cabin was as clean as it was before the initial separation.

SCOTT The high gain antenna was working well. We might talk about the next couple of days. I started with the SIM bay operations. We might comment that with the updates we were getting to the Flight Plan, the SIM bay operations kept us very busy for those last few days. There was really no time to sit around and gaze out the window at the scenery. Somebody was always on the SIM bay. I think we were late on a number of items on the SIM bay. That was primarily because we were trying to get other things done. We did not realize what concentrated attention was required to the Flight Plan in order to keep up with SIM bay. We were trying to give Al a break, because he had been hustling for so long with the SIM bay. We finally decided that the best thing to do was to let Al do the SIM bay.

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WORDEN That's right. I'd like to make another comment about the SIM bay. One of the comments I made was the fact that you never know what the configuration of the SIM bay is. I think that's particularly true with the three of us in the CM and all of us operating the SIM bay. We never knew if the booms were in or out, whether the experiments were on or off, and just what was going on in the SIM bay. I think that added to some of the confusion.

SCOTT That's right. And in retrospect, it seems to me the best plan, with three people in the CM running the SIM bay, is to assign one man to do nothing but SIM bay operations. Let him concentrate 100 percent on SIM bay, and the other two people can do the stowage, cleanup, and fix the meals. With three trying to run the SIM bay, I'm sure we all weren't very well coordinated.

WORDEN I had some Flight Plan photography to do, and you had decided at the time that you and Jim would run the SIM bay and let me take the pictures. You had to switch that around a little bit to get the rest of the things done. I think that the SIM bay requires one man's complete attention.

SCOTT When you get to eat and cleanup periods, you need to turn the Sim bay off and forget it. It was forever making us inefficient in our eating and housekeeping. You would get half way through

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SCOTT
(CONT'D)

preparation of a bag of food and you would have to do something on the SIM bay, which means you didn't do either thing well. You need to optimize that SIM bay operation such that when you get to an eat period, or an exercise period, or a presleep period, everything is off and you can concentrate on the housekeeping task. You took the lunar photography, we took some lunar photography, and everybody enjoyed the view. You had the general science part well in hand. I thought the view was spectacular. Every time we came around the corner and had another chance to look at the surface, I saw something entirely new and different.

WORDEN

It was interesting too, from my standpoint. I'd been there for quite a while just looking at the surface go by while you were on the surface. I did the plane change at 6 hours before rendezvous, and I never had a chance to look at the ground track from the time I did the plane change until after we all got together in the command module. It was completely new terrain to me, too. We were all sitting there looking at something very new.

SCOTT

The terminator is the most interesting part, by far. You can see so much. It is just spectacular. I saw something at Hadley as we went over that was surprising. It's a continuation of the rille into the mountains. As you looked out, it

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SCOTT
(CONT'D) was quite obvious that Hadley Rille was much longer than we had thought before the flight, from the Orbiter photos and the maps. It goes right into the mountains.

IRWIN There is a parallel rille there too.

SCOTT Yes. I think you took some 250s of that.

IRWIN Yes, the pictures ought to show some of that.

SCOTT The last two days were not at all slow days. They were pretty fast, with all we had to do.

WORDEN Everything that I said yesterday applies to when the three of us were in the CM. I think that the Commander and the LMP should get involved a little bit more in the SIM bay operation before flight.

SCOTT Yes, I think that's probably a good idea. Once things settle down, I think people can put more time on the SIM bay, since it is a very useful operation.

IRWIN I had one session in the simulator, at the car lot, that was very good. I agree. I could probably have had more time. You probably commented on the temperature increase on the front-side. It seems that it got hotter and hotter. It got up to about 83 degrees.

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WORDEN I didn't make any specific comment on that, Jim, because I had been briefed preflight to expect this. That is something that has been pretty general on all the flights — that the temperatures vary like that. As a matter of fact, on the radiator outlet temperatures, the upper limit was raised to take that into account, so that we wouldn't have to bring the evaporators on. That has been a pretty standard operation in the last few flights, so I did not make a specific comment.

SCOTT Yes, I think I remember hearing that, too. It was just that Jim and I were sort of surprised at the cabin temperature being that warm.

IRWIN We were kind of surprised, because there we were sitting on the lunar surface and thermal conditions were warmer there, and it was comfortable on the surface.

SCOTT The cabin temperature on the surface was very comfortable. Just perfect, I think. Then we got up in the command module and it was a little warm.

WORDEN There is a difference in the cooling, though, in the heat transfer.

SCOTT There should not be that much difference.

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WORDEN Because we were using all the radiators, and you were using the evaporator.

SCOTT TEI. The pads and the updates and everything were timely for TEI. We reviewed all the procedures for the SPS relative to the short in the switch, and the ground gave us one new update, I think, procedurally, as far as the shutdown technique on TEI. We did a single bank burn, the Bank B burn for the shaping burn, and that worked very well. The subsatellite came out as advertised. It appeared to be working very well. I think the movies will pretty well show them how it works. It looked quite stable. The TEI preps went very well, just like the rest of the SPS maneuvers. Attitude was right. I really do not have any comments on TEI, other than the burn status report which we read down to the ground. Looked like a good, straightforward, smooth burn, to me.

WORDEN Yes, sir. It was very smooth.

SCOTT The residuals were a little larger than LOI, but it turned out that it was probably a pretty good burn, since we didn't get any midcourses until we got down to midcourse 7. How about the PUGS, Jim?

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IRWIN I had to operate it in MIN to keep it in the green band. I just put it in MIN DECREASE once, and left it there. It stayed stable.

SCOTT That got us out of lunar orbit. Then we turned around to take a look at the Moon, and that was one of the nicest views we had the whole trip — knowing that we were on the way home, and getting to see all the terminators from the Moon. We made a number of comments, that we recorded, on what we saw. It was quite obvious that we were going straight up. You could see the results of the burn immediately. There was no question that we had a significant change in our velocity. That gets us on the return leg.

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14.0 TRANSEARTH COAST

SCOTT Systems-wise we had no significant problems on the way back. We got a little leak out of our chlorination port one time. We tightened it up again and it was fine. Everything else worked very well. NAVIGATION -- you might comment on your P23s.

WORDEN We tried to follow the no-comm schedule on the P23s, and there were some periods where we couldn't follow that because of some other things going on. But, I felt that the on - the - job training on the way out was very valuable, because when we started those P23s on the way home, I had a pretty good feeling for what had to be done and how to handle that whole program. Even after the first set of P23s, we had a pretty good feeling about the computation of the onboard state vector because the ground called up and said that they weren't going to update our state vector because our vector was almost as good as theirs. I haven't seen the numbers on the P23s yet, but I think the reason the P23s worked out as well as they did was the fact that I'd done considerable work at MIT on their simulator practicing P23s. That made a great deal of difference to me. I had a much better understanding of which horizon to look for and mark on and of how to maneuver the spacecraft with minimum impulse, which can be kind of tricky.

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SCOTT Especially with a light spacecraft.

WORDEN Especially with light spacecraft. It is really responsive to even minimum impulse. The system of doing the P23s, the maneuvering that we did, and the procedures for going through the P23s worked even smoother in flight than it ever had in the simulator.

SCOTT The overall concept of how the state vectors were updated and continued on board worked very well. It was obvious that we kept our onboard state vector comparable to the ground state vector all the time. There was no question that we could have completed the navigation on board and made a very acceptable, if not precise, reentry with an onboard vector all the way.

WORDEN Yes. I definitely had that feeling.

SCOTT The PTC worked as advertised, the same as it did on the way out. There wasn't any problem there.

WORDEN One more comment about the P23s before we leave that area. The Earth was a very thin crescent when we did the P23s on the way back home. We had some discussion preflight about taking marks toward the limb of the crescent on the Earth. You don't want to get out too far on the limb. All the stars that were picked were pretty much in the center of the crescent. I never had

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WORDEN
(CONT'D)

any problem locating the horizon working on that part of the crescent or taking those marks which kind of surprised me.

It's a lot easier than I thought it would be.

On boom retraction and deployment, we could see both of the booms from window 5. As far as the problem we had with the mass spec retraction, I talked about that.

SCOTT

Consumables seemed to be going along very well. We were well up on everything. We had no midcourse corrections until MCC-7 and that was in RCS. I think the DAP loads worked out very well. Your alinements seemed to work very well. You had no problem with the PTC as any time during alinement.

WORDEN

I was really quite surprised, with all those alinements. There were several periods where we went a considerable amount of time between alinements. When I did a P52 and an alinement, looking into the sextant, it was still very hard to verify the stars in the telescope on the way back home. We'd look into the sextant, and the star would be right in the center of the sextant. That really surprised me that it maintained its alinement that well for that long a period.

SCOTT

We ought to discuss the CSM EVA with some detail. First, on the night after TEI, Al started configuring the cabin,

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SCOTT stowage-wise, so that we'd be set up for the EVA. I think he
(CONT'D) put at least 2 hours into configuring the cabin the night before.

WORDEN Yes. There was a lot of detail stuff, like putting things in-
to the EVA bag, getting the purge valve out, and getting a lot
of the little stuff out of the stowage containers. We tied
the rock bags up to the sides of the spacecraft, rather than
tying them down on top of the lockers. That way we could get
in and out. Rearranging the stowage was kind of the detail
part of some of the EVA prep that we did the night before.

SCOTT The point is that when we got into the EVA day — when we got
up that morning for the EVA — the cabin was already in good
shape. Everything was set up so that we could proceed into
the EVA prep according to the checklist with a minimum amount
of shuffling. At the outset, I'd like to say that the check-
list was excellent. The procedures ran very smoothly. I don't
think anything was out of order. We had a very complete set
of procedures overall. Everything got done according to the
book, and it was very good. The only problem was time. We
got up that morning and we had a few SIM bay things to do. Al
had some P23s to do, and as soon as he finished his P23s, we
started into the checklist and the portion called "Cabin Prep
for EVA." We started that at 237:30 g.e.t. It's really called

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SCOTT
(CONT'D)

in the Flight Plan to start at 239:30, so we started 2 hours early in the cabin prep for EVA. We went through every step line-by-line to make sure it all got done. It flowed very smoothly with no hitches, and it just took a little time to get everything done. We ended up just about on time for the pressure integrity checks. That means that it took us almost 2 hours longer than preflight planning. We were very happy that we had started early. We were glad that we had Al configure the cabin the night before to take care of the little details. I think it will pay off if you get started early on the EVA, because it really takes a lot of time making sure that you get everything done.

WORDEN

Most things you do on board take a little longer than you would expect them to preflight. That's because you take a little bit more care with what you're doing in flight. You do it much more methodically than you do preflight. That was particularly true of the EVA prep. We went through the checklist very carefully, very methodically, and we never rushed at any time. It flowed very smoothly but a little slower than we anticipated.

SCOTT

Which I think was good in that case, because it was the first time through for that EVA. It was nice to have a comfortable time pad all the way through. We knew we had a good time pad

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SCOTT all the way through, so perhaps we were not operating at maximum efficiency relative to time. We were taking our time because we knew we had the pad.

Hatch opening occurred about 5 minutes after the planned hatch opening. The integrity checks went very well. The procedures played just exactly as they were laid out in the checklist and just like we've seen them in the chamber. I'm glad we ran those chamber runs because that helped us, Jim and I, to understand what you were doing with your equipment.

WORDEN I think so, too. We were all well prepared for the EVA. There was a lot of discussion about cracking the side hatch valve to maintain the cabin pressure during the EVA prep. That's particularly true when I was flowing through the umbilical. I thought that operation worked very well. I didn't see any problem at all with opening the side hatch valve just a little bit to relieve the cabin pressure.

SCOTT Except that it was easier for me to do it than it was for you.

WORDEN That's right.

IRWIN My tether was too short. I would have had real difficulty if I had really tried to change the MAG on the sequence camera.

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IRWIN
(CONT'D)

As it turned out, I thought I pushed the button. I did push the button on the sequence camera, but apparently it did not drive.

SCOTT

We depressed the cabin, got all the integrity checks, and everything worked fine.

WORDEN

Once we got the side hatch open, from that point to the time we closed the hatch, the whole operation went almost exactly as it had in preflight training, both in the zero-g airplane and the Water Immersion Facility. I don't recall anything during the EVA that I thought was off-nominal. As a matter of fact, it was so much like preflight, that I really had no anxieties about the EVA at all. The whole thing went just as smooth as it could. The mapping camera was in the FULL EXTEND position. That was expected at the time, since we had some trouble retracting the mapping camera up to that point. But we practiced all that, and it was no problem. It was just as we practiced. That's the key to the whole thing — good solid practice before flight. Be well prepared for what's going to be out there and for the kind of body motions that are required to get back into the SIM bay and into the foot restraints.

I opened the hatch. After getting the hatch open, the first thing I did was take the TV and the DAC and mount them on the

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WORDEN
(CONT'D)

bracket in the hatch. The hatch didn't get fully opened the first time. When I got part way out, I guess you opened the hatch the rest of the way so that the camera was pointing down along the SIM bay. I just went outside the hatch, grabbed the first handrail, and positioned myself just outside the hatch until Jim got in the hatch to observe and to watch the umbilical. I went hand-over-hand down the SIM bay and to the left around the mapping camera. I just floated myself over the mapping camera instead of going around it down into the SIM bay. I put my feet in the foot restraints and just stood there for a minute, resting and looking at the SIM bay, and waiting for Jim to get himself positioned in the hatch.

As far as the cassette operation, the pan camera went just as I had anticipated it would go. I pulled the metallic cover off the pan camera and released it. Then, I pulled the fabric cover off. The force that it took to pull both of those covers off was just as I had expected and remembered from preflight. It was the same operation. I pulled the pin on the pan camera cassette, tethered myself to it, and pulled the release handle. It came out even easier than I had expected. The mass of the pan camera cassette was a little bit more than I had expected, but it was no problem handling it. I just very carefully drifted it back towards the hatch, keeping my hand on the

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WORDEN
(CONT'D)

handle and maneuvering myself back. I did release it at one time, because I had to use both hands to maneuver myself over the mapping camera. But I didn't release it clear to the end of the tether. I just let go for a minute, repositioned myself, and then grabbed it with the handle again. I thought that went very smoothly.

The transfer back through the hatch went just as we'd done before, too. I handed the pan camera cassette back in through the hatch. You tethered it and then released my tether. That was pretty much as we'd done before; no problems there.

SCOTT

I put it down in the LEB and it stayed. I left it on the tether and it never got in your way. No problem.

WORDEN

After that, I turned around and went back out in the foot restraints. I don't recall now whether I looked at the mass spectrometer between camera film cassettes or whether I did that before. I think it was between the pan camera cassette and the pulling of the mapping camera cassette when I leaned in and looked at the mass spectrometer to see if I could determine why it had not fully retracted.

The Inconel cover on the mass spectrometer was cocked about 30 degrees from the closed position. I reached over and grabbed the cover and moved it a little bit. It's a fairly

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WORDEN
(CONT'D)

flimsy cover, but I wanted to see if it was jammed against anything. One corner seemed to be hung up. I released it, but the cover stayed where it was. I really couldn't close it. Then, I looked down inside the mass spec itself and noticed that the guidepins were through the guide slots in the experiment itself, indicating that it had at least positioned itself on the base of the boom itself. I wasn't sure at the time. That's something I hadn't looked at preflight. I wasn't sure just how far those guidepins should come through the slots to indicate that the mass spectrometer was fully retracted. So I called down to the ground and said that the tip of the guidepins were just through the guideslot. They called back and said that it wasn't fully retracted then, because the guidepins should be through the slots far enough so that the cylindrical part of the guidepin could be seen. So, that indicated to me that the mass spectrometer wasn't fully retracted. That was all I could see on it. I couldn't see around the mass spectrometer. I couldn't see down into the SIM bay at that point because the cover was obscuring the view.

I left the mass spec and went back to the mapping camera. When I pulled the cover off the mapping camera, I noticed that that particular cover was a little more difficult to release than I had anticipated. That particular cover is set under a flange

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WORDEN
(CONT'D)

on either side. It's held down by some pins at the release end of the cover. I had to twist it a little bit and pull it a lot harder than I had anticipated to release it from the flanges on the side. But, it did come off all right; there was no problem. The fabric cover underneath got hung up on on corner. The fabric has a rubber slot that it fits into around the edges, and it's almost an airtight seal. That rubber-slotted flange hung up in one corner, and I had to pull it three or four times before I got it released. After that, everything was just as I had anticipated.

I tethered the mapping camera cassette, released it, and it was a very easy operation after that. I brought it back into the hatch, as we had practiced preflight. When I got the mapping camera back to Jim in the hatch and he took it, I asked the ground if there was anything else that needed to be looked in the SIM bay. There ensued some discussion about looking at the mapping camera to see if we could determine what caused the mapping camera to stay in the EXTEND position. I think the concern at the time was that the laser-altimeter mapping-camera contamination cover was binding against the side — forcing it to stay in the EXTEND position. I went back out and looked, and there was about 3/4ths of an inch to maybe 1 inch clearance between the cover and the mapping camera itself. From that, I

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WORDEN
(CONT'D)

concluded that the cover hadn't anything to do with it. I looked underneath the mapping camera, and I looked around all of the edges to see if there was something binding, maybe something that had lodged alongside the mapping camera. Everything looked clean to me. There was nothing that was impinging on the mapping camera at all. The stellar shield was still out, but of course, it would be with the camera extended. At that point, it was maybe 12 to 15 inches away from the SIM bay mold line. So, there was nothing I could tell from there that would shed any light on why the mapping camera did not retract.

After looking at that, I went back in the hatch, pulled the quick release on the TV camera bracket, which we had decided to do preflight. Rather than releasing the handle itself, we pulled the Marmon clamp, releasing the pole. I sent the pole in the hatch, backed into the hatch myself, and pulled the hatch closed. I thought that went very easy. It took hardly any force at all to close the hatch. It operated very smoothly and very freely. I pulled it right down to the point where it was closed. A couple of pumps on the handle, and the latches were over and off. It was very simple operation.

SCOTT Your PCV flow did not in any way hinder the hatch closing.

WORDEN That's right.

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SCOTT No buildup of pressure inside.

WORDEN I didn't notice anything as far as the hatch was concerned.
It was a simple operation.

SCOTT The pressure equalization valve was open.

WORDEN That's right. The equalization valve was open.

SCOTT The repress went nominally, with no problem.

WORDEN In true zero-g it was really much easier than it had been even in the zero-g airplane. I think there's some rotation that you get in the zero-g airplane that does effect your motions a little bit. True zero-g is just much easier. If you can do it in a zero-g airplane and in the Water Immersion Facility, in flight it is easy.

SCOTT The next order of business was to make sure the contaminated gloves and articles were cleaned and stowed in a separate bag. We ended up with two sets of EV gloves, one set of IV gloves, a purge valve, the washcloths, and the tethers in the contaminated bag, which we so marked. We doffed the suits and put all three suits in the L-shaped bag by taking out the center couch, stuffing them in there, and then putting the center couch back down on it. It seemed to work pretty well. We got all three of them in.

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WORDEN A comment on the cleanup. One of the things that had to be done, after we got the suits off and we got straightened around, was to stow the cassettes. Before we stowed them, there was some taping that had to be done on the cassettes — taping up the slits and taping up the opening in the mapping camera cassette where the two halves of the shelf joined. The only surprise I got was that the tape wouldn't stick at all to the mapping camera cassette, and I finally had to wrap it almost like a Christmas present to keep the tape on that slot. There's a rubberized coating on the outside of the mapping camera cassette that just wouldn't adhere to the tape.

SCOTT We must have used at least 100 yards of tape. That gets us down to the rest of the TEI activities. I think the SIM bay operations were pretty much standard by that time, with no unusual things that I can remember. Can you think of anything in the SIM bay that was really unusual on the way back?

WORDEN No, except that we really seemed to have a lot of SIM bay activity on the way back. That was because of some of the X-ray experiments that were added to the Flight Plan. I think on the SIM bay operation on the way home — with us rotating the operation in the SIM bay — we were still in the position where we didn't always know what was going on with the SIM bay.

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14-15

WORDEN
(CONT'D)

We didn't always know what the configuration was. At that point, it really wasn't any problem, and the ground was very good about giving us reminders on those things.

SCOTT

I guess that kept us busy. There wasn't time on the way back to sit around and look out the window and reflect about it all, because we were doing something almost all the time. I think the housekeeping kept us up against the wall because every night when we finished an eat period, we had on the order of 20 minutes to start the rest period. During that 20 minutes, we had to get into PTC, clean up the SIM bay, chlorinate the water, sometimes dump, get our hammocks out, give a crew status report, record consumables, cycle the H₂ fans, and often, change the canister. That takes a lot of time. I think 20 minutes isn't enough to do all that. We sort of bit into our rest period every night, and I think there's just no way around it. I don't think it hurt us any.

Cleaning the screens was another thing we were doing quite often. Especially post-lunar-orbit activities, when we had all the dirt. We had to get around and clean those screens at least daily. We'd lost, somehow, two of them. One or two?

IRWIN

One.

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SCOTT We took netting off the LCG and put it over the return hose on the suit circuit and wrapped it with tape — made our own little screen. This seemed to work pretty good.

WORDEN The cabin fan filter is on the output side of the cabin fans. We noticed, on the way home, that the inlet to the cabin fans seemed to be the thing that was collecting all the dust and the dirt. That's like a register in a home; it's just a metal grill. There seemed to be a lot of dust and particles collecting around that, and we could see it on some of the hardware inside that metal grill.

IRWIN It was an inner grill. There was an inner grill there that seemed to be collecting a lot of dust and debris, and we couldn't get to that. I don't recall seeing anything in the cabin fan filter. It didn't seem to be collecting anything, because everything seemed to be collecting on the return line.

SCOTT Yes. We looked in the cabin fan filter, and we took it off on the inside.

WORDEN That's right, and it looked pretty clean to me. It just surprised me that we had a cabin fan filter there.

SCOTT We did another light-flash experiment on the way home, and I don't think we talked about the one on the way out. That was

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SCOTT (CONT'D) noticeably different, in that we saw fewer flashes. All of did, on the way back, when we got closer to the earth. We commented on tape during the flight on what we saw. They should have that data. Jim and I commented that we did see flashes on the surface. I thought the response was a surprised one at that. We could both see them every night.

IRWIN Yes. I did one solo light-flash experiment during lunar orbit.

SCOTT We did the lunar eclipse photography and the TV. The ground had a fairly good picture of that for a while, until it got too bright.

IRWIN I thought the TV interrupted that at an inopportune time. It came right in the middle of lunar eclipse photography, although I think we probably got all the pictures required.

SCOTT That's right. We had the nighttime requirements, and 250 requirements, and then the TV requirements on top of that. It was a pretty big shuffle there at the end of the press conference to make sure we got it. The priority was to get the photographs and then, if we could, get the TV. But, it ended up I was doing the 250 and Al was doing the night, so I did the TV out my window for a while and then passed it to you, out your window, so we could work it in between the photos.

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WORDEN I don't recall any plans prior to that time to look at the lunar eclipse with the TV. I think that was something that got added at the time.

SCOTT I think we got the photos all right.

WORDEN At the time, we really thought it would be nice if we could keep the TV going and take the pictures too. So we re-juggled a little bit, and I think we found that we could get it all done without any trouble.

SCOTT EATING, RESTING, EXERCISE, and COMFORT. We continued eating and started running out of food, except for bacon squares, which we never managed to run out of. Everybody did a little exercise on the way home. As we got closer to the Earth, we found that the cabin got cooler and cooler. I don't know what that's associated with, but the last night was quite cool.

WORDEN As a matter of fact, I remember the comment that the cabin was down to 62 degrees on the last night.

SCOTT Yes. It was pretty chilly.

WORDEN It was pretty cool.

SCOTT But, the sleeping bags and coveralls and CWGs were adequate to keep us warm enough. FLIGHT PLAN UPDATES. There were a

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SCOTT
(CONT'D)

lot of Flight Plan updates. Then we get ready for ENTRY. The procedures for entry all went very smoothly. We did the final midcourse maneuver number 7. It was an RCS burn, 5 feet per second. It didn't complicate the time line in any manner. We had all the entry stowage done, almost all of it done, the day before entry. On entry day, we found ourselves with an awful lot of time on our hands, which I think was a good idea. Everything was cinched down tightly, and I thought the ground pretty much agreed with where we put everything. I thought they had a fairly good handle on our stowage locations, and we stowed just exactly like we had it on the stowage map. Our comment going into the entry was, "Gee, we've never had this much time in a simulation before." We sat there and coasted along.

WORDEN All the events flowed very smoothly, and there was plenty of time between events to get set up for the next one.

SCOTT Yes, that was very comfortable.

SCOTT We got ready to do the next-to-the-last GDC aline — GDC to ALINE and ROLL. I remembered that, in lunar orbit when I last alined the GDC, I had to jiggle the PUSH button to get the thing to aline and roll a little bit. I mentioned that to you, and you played with the button for a while and finally got it to realine and roll.

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WORDEN That's right.

SCOTT I think you've got a bad GDC ALINE pushbutton in the spacecraft. They ought to take a look at that.

WORDEN I'm glad you brought that up, because there's another thing about the GDC ALINE, too, that surprised me a little bit, particularly the first time I did it. The GDC ALINE pushbutton has two detents, and you can push it to the first detent and nothing happens. You have to push hard on it. In fact, I ended up using my thumb because it took so much pressure to push the button in — to get it clear to the second detent and to get the GDC ALINE to begin with. Then in addition to that, we had the problem with roll.

SCOTT The alinements went very well prior to re-entry. Star check was good. All the attitudes worked out as planned. We went through all the systems checks, and I can't remember any anomalies in there. Can you, Jim?

IRWIN No.

SCOTT You checked over all the systems per the checklist. You configured the camera. We discussed the fact that the checklist said to take pictures of the chutes, and the Flight Plan said to take pictures of the fireball and the chutes. There was

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SCOTT some question in our mind concerning the setting of the camera.
(CONT'D) I guess you got that squared away. No pre-heat on the RCS.
We went into the SEP checklist, and that all worked well.

IRWIN The CM RCS check, prior to separation.

SCOTT We went through the CM RCS check, and when Al did the minimum impulse on the hand controller, none of us heard anything. We heard the propellant run through the lines as expected. As I had remembered from Apollo 9, we could hear very positive minimum impulses in the CM RCS. I was very surprised that when Al ran around the stick we didn't hear anything. I thought we might have heard solenoids in some cases. I was very surprised that it wasn't a positive squirt out the CM RCS. We quizzed the ground, and they confirmed they could see the solenoids. Then I realized that they had second thoughts about it and decided that they couldn't really verify we had RCS. We were thinking along the same lines, too. "We ought to do something else here before we go SEPARATE to confirm we've got CM RCS." So, we had transferred SM, transferred back to CM RCS, and the ground had suggested we try ACCELERATION COMMAND — we were about to reach the same conclusion — to get some good rates. You put in an ACCEL COMMAND and checked both rings and got some good solid rates. We could see the flashes then. Then

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SCOTT (CONT'D) after that, particularly after we separated, we could hear the minimum impulse, and there was no question. We had good, solid burst on minimum impulse.

WORDEN That's right. I think we were all surprised at the noise level when we first checked those. It was quite different from what we heard in the simulator.

SCOTT Yes. The simulator is much too loud. Except after we got separated and you were pulsing around the entry attitude, then you could hear them.

WORDEN That's right.

SCOTT They were very positive and very sharp.

IRWIN Again, on that first check, it seemed that we could hear ring 2, but not ring 1.

SCOTT But only the solenoids, you couldn't hear the firing line through it, later on.

IRWIN But there was still a difference between the two rings.

SCOTT Yes. That's one that somebody ought to think about. I'm almost sure that on Apollo 9 we could hear the minimum impulse right away. But, it all worked. We got the separation and

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SCOTT
(CONT'D)

that went very cleanly, another big bang. All the transfers were automatic. You maneuvered us around to B entry attitude. We just waited for the time of the entry interface, followed the procedures as per the checklist, and everything ran very smoothly. The timing worked out. The earliest check I got on the G&N was about 11 minutes prior to DEI, and it was tracking the 29 seconds we had on the pad for RRT. So, all the times agreed, and all the guidance systems looked like they were in good shape. The next event was 0.05 g.

WORDEN

Before we get to 0.05 g, I have one thing to comment on. We had a dark horizon. One of the things that I was curious about, one of the things I checked very carefully, was to see if there was a horizon out there; and there was, in fact, a horizon. It was very clear. We turned the lights in the spacecraft down a little bit to help. The horizon was very clear. When I first saw it, it was about 7 or 8 minutes out from entry interface. It was about 5 degrees above the 31.5-degree line in the window. As we got closer to entry interface, it was obvious to me that it was progressing right on down to the proper point at entry interface. It was very easy to track, and it was a good indication of attitude.

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15.0 ENTRY

SCOTT The reentry went as planned. The g levels agreed all the way into the 6gs and back out. The G&N was given control after we confirmed that we had a good g time. I compared the G&N and the EMS range to go and they looked close all the way, within about 20 miles. You were watching the scribe and it looked very smooth and nominal all the way in.

WORDEN Because of the AC problem we had in the circuit breaker, we didn't have any backlighting in the EMS. There was some concern that we might not be able to see the scribe; but, it was very clear the whole time through entry. One other comment about the EMS was that you called .05g and just as you called it, the .05g light came on on the EMS. It was very clear. There was no problem in seeing that as soon as it came on.

SCOTT All automatic.

WORDEN All automatic.

SCOTT That's a good point. I gave a call right after blackout. We ended blackout at 3:37 and I called about 3:45 or so with our delta between the EMS and G&N and everything was in good shape. I got no response. I never heard from the ground on any of the calls. I made probably four calls on the way down. I gave

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SCOTT the NOUN 67 values when they first came up and then later on
(CONT'D) I called them. We heard the Recovery forces radio, but I
don't think we ever had two-way contact with anybody until we
got in the water. I think they heard us in MCC, but we couldn't
hear them. We could hear the Recovery forces and apparently
they couldn't hear us.

WORDEN That was my impression, too. I don't recall any conversation
with anyone. There was a terrific amount of radio chatter
going on. I don't recall having two-way communications with
anyone.

SCOTT We saw the ionization prior to .05g. You could see it out your
window, and you started your camera.

IRWIN That was about 5 seconds after RRT had started.

SCOTT Very clear. We mentioned our control modes with G&N automatic
all the way in, very smooth and very positive. I didn't feel
any oscillations on the way down. The drogues came out auto-
matically at 24K. Right?

WORDEN Exactly at 24K.

SCOTT Then, the mains came out exactly at 10K automatically, and we
did not push any buttons on the panel; just let them close

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SCOTT because it was all automatic. Why don't you talk about what
(CONT'D) you saw on the main chutes out the window?

WORDEN The main chutes came out at 10 000; the drogues released just
 a few seconds before that. The main chutes came out at 10 000
 and at about 8000 we got the cabin configured and started the
 fuel dump.

SCOTT When you saw the mains come out, you saw three chutes. Is
 that right?

WORDEN That's right. I saw the three chutes, come out, reef, then
 disreefed, and I had three full chutes in view. When we
 started the fuel dump, my view of the main chutes was obscured
 by a cloud of fuel that was going by the window.

SCOTT A big red cloud.

WORDEN A big red cloud going by the window. When we finished the
 fuel dump and the view cleared, I could see that one of the
 chutes was not fully inflated anymore.

SCOTT I think that was just about the time we got a call from Re-
 covery that we had a streamer. Right?

WORDEN That was just about the same time.

SCOTT Yes.

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WORDEN I think they had seen it before and gave us a call. It was just about that time when I picked up the chutes again in view.

SCOTT We might add that that was a very good call; for them to inform us at that time. That was an indicator that we had less time to get everything done on the way down than we had normally planned; especially after you confirmed it. The dump and the purge went according to plan. Jim was going through the checklist and I had the feeling you were having to really hustle to get things done.

IRWIN No, not really; but, I had to yell.

WORDEN I think that was noise; that was the problem. Jim and I were yelling at each other, back and forth across the cabin, because there was so much chatter on the radio.

SCOTT Yes. That's true. There seemed to be an excessive amount of chatter on the radio. I don't really know why. Maybe we're getting too many recovery items nearby with airplanes and ships and helicopters. It might be getting too crowded out there because there was just a constant chatter going on. They were calling us. They were calling each other, coordinating their efforts.

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WORDEN I remember one voice in particular that was giving a running commentary of everything that was happening on that final descent. Other people were trying to call us over that voice. I thought that that running commentary was really hurting our operation more than it was helping because we didn't need it. What we really needed to do was talk to the other people who were trying to get hold of us.

SCOTT Yes. What we really need is to have one chopper out there, or one point of contact. One vehicle in the air, everybody else maintaining radio silence so that he can call us and we can call him and can coordinate that way.

WORDEN I would think they could do it on a different channel.

SCOTT Something should be worked out because that was sure a busy time voicewise. I'm not sure the reason they didn't hear us, not because somebody was blocking us all the time, but because we were calling.

WORDEN We came pretty close to that chopper, which could have been disastrous.

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16.0 LANDING AND RECOVERY

SCOTT We came down expecting to have a rather solid impact, which we had. I had the feeling we hit pretty flat. There was no apparent roll to the spacecraft at all. I could see water up over the windows after we hit. You all got the main release and the circuit breakers, and we ended up in a very stable condition with no rocking or anything.

WORDEN That was surprising that we went straight down and straight back up, and there wasn't any motion at all, hardly, except for the sea swell.

SCOTT Went through the postlanding checklist, and stood by for the collar and the swimmers. I thought the cabin atmosphere was just fine. Nobody had a tendency, I think, to get seasick.

WORDEN One thing we commented on is that, when I first turned the postlanding vent on, Dave got a face full of water.

SCOTT Yes, but it didn't get me any wetter than I already was because when we started into reentry, all the water in the tunnel came down on me. So I got bathed from top to bottom.

WORDEN When I turned the postlanding vent on, you got a face full.

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SCOTT That's something you might think about in the future, making sure you mop the tunnel up. There's an item on the checklist that says "check the tunnel for water," but it doesn't say what to do about it. We had a little moisture up in the tunnel, but I was very surprised that so much water came up in that tunnel on the way in. Just like a bucketfull. Wasn't any problem.

We gave the swimmer thumbs up, which he relayed. I guess by then they had heard us and that everybody was in good shape. We cleaned up the cabin as per checklist. We powered down, egressed, got picked up, and I thought that all went very smoothly. Just exactly as we had trained in the Gulf. The same Scuba team leader was there, and he did the same thing. The only anomaly there was that the swimmer couldn't get the hatch closed all the way. That left me with a rather uneasy feeling leaving the spacecraft — even though the seas were calm — with an open hatch. That just didn't make me too warm. I don't know why he couldn't get it closed. It looked like the dogs were all the way backed off, and I saw him vent the counterbalance. It was open about 3 inches.

WORDEN It was open more than that. It was open a good 6 inches at the open end.

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SCOTT I don't know why it didn't get closed. That's something that we ought to make sure that the swimmers are maybe briefed on — malfunction procedures with that hatch. It would be a shame to have it sink.

The pickup, I thought, went very well. The chopper operation, in my estimation, was smoother than the one we had in the Gulf. I had a smoother ride up and into the chopper than we did out at the Gulf.

WORDEN I thought that whole operation went very smoothly.

SCOTT It did. Everybody felt good. When we got on the chopper, it looked to me like nobody had any trouble changing clothes up there and putting on a new flying suit. I think we all recovered from zero g to one g within 5 or 10 minutes.

WORDEN I felt better on the chopper than I did when I got back aboard ship.

SCOTT Yes. It was more stable. Those ships without their fins do a little bit of rolling.

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17.0 TRAINING

SCOTT In general, the CMS is an excellent trainer. The people are well qualified; it is high fidelity. Some of the oral cues might be a little off, such as the emission of CM/RCS. The launch is sometimes a little loud in the CMS, because we didn't have any problem with the noise during launch. I think you might comment on your optics in the CMS, compared to the real thing.

WORDEN Let me go back to crew station first. I think we saw the best stowage in the simulator that I've ever seen, on this particular flight. That must be a result of accumulating the stowage equipment for the EVA training. It really created a hardship on everybody, switching that stowage back and forth from one simulator to the other, to try and do the EVA training at the same time we were doing training in the other simulator. This is particularly appropriate for things like cameras, and some of the pieces of stowed equipment that were needed in the normal training and were also needed in EVA training. I think that some effort should be placed on getting stowage for both of those trainers down there, because they're both used quite a bit. The visual systems in the simulator are okay for procedures, but very inadequate for technique. You can run through

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(CONT'D)

the programs, and you can look through the optics, but they really don't react anything like in flight. The optics in flight were so smooth, as compared to the optics in the simulator. Get a star in the sextant, for instance, and you can move it around very slowly and very smoothly in flight. In the simulator, no matter how much it was worked on, the star would be jumpy. On landmark tracking in flight, the optics tracked very smoothly. Once you get on the target, even if you're at low altitude, you can track it very smoothly through the nadir with very little problem. In the simulator, there was a light to be tracked which simulated the landmark, and that was subject to electrical fluctuation. The position of that light would change with respect to the background film, and I found it much more difficult in the simulator than I did in the flight. However, procedurally, it's okay. The P23s were the same way. In the simulator, the horizon was not like the horizon I saw in flight, although it was very close to it - a lot closer than I expected it to be. I found that P23s in the simulator took much longer to do and required much quicker attention to things like small rays and optics drift than they did in flight. I found it much easier and much quicker to do in flight. Procedurally they're okay.

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WORDEN (CONT'D) I thought the software in the CMS was fine and it worked just like in flight.

SCOTT The LMS crew station fidelity was fine. Within the simulator, the L&A was great, but the model was overly enhanced, or the topographic relief on the model was far more than we experienced in the real situation. That's a function of the enhancement of the photography which brought out more shadows than really existed. In the final analysis, that gave us a problem during the landing, and during the EVA traverses in locating ourselves relative to the features on the surface. There's not much you can do about that when you accept 20-meter resolution photography. But, it was quite different. The projection within the simulator was great. The L&A is a very useful thing, and I might add that at Jim's suggestion, they built a Rover simulator — which isn't included here — utilizing the L&A and the television display, for driving on the lunar surface. We both thought that was a very useful simulation.

IRWIN We probably spent just about the right amount of time on it.

SCOTT A couple of times around each traverse was fine.

IRWIN It really made us feel at home once we got to the moon.

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SCOTT It made us familiar with the sequence of craters we'd encounter and their names and relative positions. Software worked fine. Have you got anything else on the LMS, Jim?

IRWIN I'm wondering if we couldn't get a little more usage out of the film strips. We finally got the one film strip leading into the landing, going in the right direction, I think, one time.

Concerning the CMS, I would like to have a filmstrip projection out the right windows to use, just to get some practice identifying features. Window 4 or 5.

SCOTT The integrated simulations we ran worked fine. We had a few problems here in Houston with dynamics between the two simulations. I don't remember ever having had any particular problem at the Cape, other than occasional computers that would go down. That's to be expected. Simulated Network simulations — with Houston. Those are invaluable. The more we have, the better it is. I think we had the minimum number. I'm sure Mission Control Center, and as far as that goes the crew, could both use more. Those are the peak of the training curve, working with the guys in the Control Center, where we really iron out the problems. Once you get yourself trained in the simulators, so that you can handle nominal and off-nominal situations

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SCOTT
(CONT'D)

procedurally, then you can step into the operations with the whole Network and smooth that out. I think we had some rough edges as we went along in both vehicles.

I'd say the last SIM in each phase was where we got the kinks ironed out. I think it would be nice if you could have a couple of SIMs before launch for everybody together. I know for instance, on our last descent SIM, you and I had a pretty good day, but when the backup crew got in, they had a lot of trouble that day. They had a number of problems. You sure make a lot of money with those things. The ground needs to do more math-model runs, or everybody ought to get together for a few more SIM NET SIMs. I think ours were adequate. I think we had enough DCPS — that's a very good simulator.

WORDEN

Yes.

SCOTT

We had plenty of time on it. It was very useful. A lot of launches in a short period of time with a great variety of malfunctions. I felt very comfortable during the launch. I think you did too.

WORDEN

Yes. The CMPS is good for initial training on the programs. They have more capability now than when we were using the CMPS. In fact, the only thing I trained on the CMPS really was the

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WORDEN (CONT'D) MINKEY operation. I found that that was good program training and good procedures training. The operation of the CMPS is somewhat different than either the CMS or in flight, but it's good procedural training.

SCOTT Before we leave the electronics simulators, I'd like to say that the support was great. We had outstanding cooperation with everybody on the simulators. I was very pleased with the training in those things, particularly at the Cape.

WORDEN I couldn't agree more.

SCOTT Egress training — we ran the standard pat egress training at the Cape. That was fine. Gulf egress training went very well. We'd done a tank exercise on Apollo 12, so we didn't do that. I don't think it was necessary. Spacecraft fire training we really didn't do, but we did as Backup on Apollo 12.

We went to the planetarium once, which I thought was a useful trip - not really required, but it was useful.

Simulator training plans. With the overall system of spacecraft and checkout, I think it's unnecessary to go to the depth of malfunctions that we tend to go to in the simulator because we just don't see that many malfunctions, or that type malfunctions in flight. The people in the training program are getting

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SCOTT
(CONT'D)

smarter, the people in the Control Center are getting smarter, and they tend to dig a little deeper in malfunctions and go down to double and triple failures in some cases. I think, for the crew to be able to handle all phases of all malfunctions to that detail is really unnecessary at this stage of development of the hardware. I think, the system has matured enough so that the crews can now concentrate on accomplishing the mission objectives and spend their time on learning how to do that, rather than spend a great amount of time, like we have in the past, on malfunctions. We have to be aware of how to handle malfunctions, primarily the dynamic situations which occur making a major maneuver, or the landings, or situations in which you have to make an immediate correction to stay out of trouble. But as far as going through every malfunction procedure in the book, and experiencing all the various paths of each malfunction procedure, I really think that's unnecessary at this stage of the game. If you understand the Systems Book and the Malfunction Procedures Book, and how to use it, you can work through any malfunction with the logic diagrams presented. I think those (logic diagrams) are very well presented and very easy to understand.

In constructing the requirements for training, again, I had the feeling that everybody wanted a little bit more out of the crew

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(CONT'D)

in each area. The simulator people are a lot smarter than they used to be. They could see more things that we ought to learn relative to handling spacecraft malfunctions. But if we do that, we compromised our learning process and the mission objectives. My feeling is that we should now concentrate on learning how to accomplish the objectives and assume that malfunctions are going to be about as rare as they are in aircraft. Know how to handle the emergencies, know how to understand malfunctions, discuss them with the ground, and rely on the ground as a monitoring system and to solve the non-time-critical problems for you. Only in that way are you going to be able to spend the time to learn how to accomplish the mission objectives. Maybe some things, like for instance, LOI aborts, I think we've put too much time in on them. They're useful, they're necessary, there's a certain degree of proficiency you have to reach; but if we put in our time on learning all the possible combinations of LOI aborts, and exactly how to do them precisely with finesse, then we just don't have time to learn how to do the orbital geology, or the surface geology, or some of the things which I now think we need to concentrate on, knowing that the spacecraft systems are working fine.

WORDEN

When you get down to the final stages of training and you look ahead and formulate a simulator training plan, I think all of

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WORDEN
(CONT'D)

the previous training that the crew has undergone should be taken into account. We ran into some problems where only a part of the past training that we've had was against future training plans. We tried to accomplish some things which we had done here in Houston, which didn't have to be done at the Cape. When plans are formulated, I think that the total training the crew has undergone should be taken into account and not just that training which is done at the Cape.

SCOTT

That's a good point, because a lot of the far-out abort modes you learn one time, you know what the checklist says, you can follow the checklist, and that's all you need to do. If you can do that here at Houston, I see no requirement to do it again at the Cape.

IRWIN

I agree.

SCOTT

Systems briefings. We went through the required systems briefings early in the game and I think they were good. They got us to the point where we could understand the fundamentals of the systems and then utilize it on the simulators.

IRWIN

We're referring to the contractor systems briefings.

SCOTT

Orbital geology training.

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WORDEN I thought that the training that I received on orbital geology was better than I had anticipated. I was very well prepared when we got there. The only comment I'd have is that most of that detailed training we had came very late in the game. It had to be sandwiched in with other things at the Cape and some meetings through the isolation booths on the final stages of the training. It would be helpful if we got into the detailed part of that a little bit earlier in the training cycle.

SCOTT On the part that we participated in, Jim and I, I thought it was excellent, well presented, and very interesting. Didn't you Jim?

IRWIN Yes.

SCOTT Landmark and identification training — landmark tracking.

WORDEN We got involved in the landmark and the site selection at the beginning, so that was kind of a continuous process all the way through. It certainly was a worthwhile thing to do, to get involved with it that early in the game, because then you are quite familiar with it when you get in the final stages.

SCOTT SIM bay training. Al, you did most of that. I can only say that the CDR and LMP ought to have more SIM bay training. We just didn't have time for it, but it would have been very useful to have more, particularly on the controls and displays.

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WORDEN SIM bay training was kind of a mutual process between myself and the simulator instructors. We were all learning the SIM bay at the same time. It was a boot strap operation. In the future that portion of it should be cleaned up considerably, since the simulator people are quite well up on it. I found the training that I had was perfectly adequate for what we saw on the flight.

SCOTT Lunar surface. One-sixth-g and KC-135 — I thought all those sessions were very good and very useful. The level that we had and the detail we had were fine.

IRWIN The cabin work with the PLSS on might be well to work on.

SCOTT That might be a good thing to add. You could add that without any trouble — get in the cockpit all suited up one time.

SCOTT One-g walkthroughs. The rock pile. We've discussed this, particularly on the way back. I don't think we would have traded any one minute of that, particularly the suited operations. That really prepared us for the surface work. There were some suggestions toward the end that we run shirtsleeve. We both decided to run suited up to the end, and I'm glad we did. I think every exercise we had out there in suits was well worthwhile.

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IRWIN The work on the lunar surface was not much different from what we experienced on the rock pile. We didn't sweat as much, but it seemed like the work was about the same.

SCOTT If we could get LCGs in the training suits, and the training backpacks, we'd have an excellent simulation of the lunar surface, in spite of the fact that you'd have the heavy backpacks. That was excellent training. I agree with Jim. The surface operations were not too much different from what we'd experienced on the rock pile. You gain an awful lot by going out there and working on the rock pile back of the simulator building.

The addition of the geology stops there at the Cape is good. We didn't have the opportunity to exercise all those rocks they'd put out there for us, but I think the following crews will find it very useful to drive the Rover and go through the procedures of getting off the Rover and doing the geology, the sequence of events with the high gain antenna, the LCRU, and everything. It was very good training.

The field trips were excellent. We had one a month. We never had a bad one. We got rained out one time. We got dusted out one time. We were very fortunate with the weather. The people who conducted our field trips were excellent instructors. I felt they were very useful; I wouldn't want any less. I

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SCOTT (CONT'D) wish we would have had one more good exercise out in the field in the last couple of months.

IRWIN We got cheated out of one.

SCOTT We lost one. The Rover. I thought the one-g training in the Rover was good. We added the one-sixth-g deployment operations at the Cape, and I'm glad we did that. I'm glad we got the qual unit down to take a look at it, because it was much higher fidelity and had little pieces and systems not in the one-g trainer. We got to learn a few things from it. The program that was finally evaluated with the Rover was excellent.

IRWIN We had the right level of training.

SCOTT Running in the centrifuge at one-sixth g was good. Except for the fact that we were heavier and didn't tend to float off the Rover, I thought that was a fairly good simulation.

IRWIN They just didn't have the crater densities that we had on the Moon.

SCOTT SESL. We didn't use the SESL. We used CSD's 11-foot chamber. We did about right on that. We had two runs early in the game and one late in the game. I think that was probably a reasonable approach to the situation. The runs that they planned for us were fine. I wouldn't cut any out, and I wouldn't add any more.

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Briefings on the lunar surface. We had the briefings associated with the exercises. The people working out the procedures for the surface did an excellent job. It's a very complex operation and very difficult to put it all together for the first time around. We had a lot of loss of fidelity in training equipment, because it was always behind. We never did get our training gear up to equal the flight gear. I hope that's rectified in the next go around for the next flight. We saw a few new things on the lunar surface — I'll have you know that vice was on backwards. They studied the pictures, by golly, and the vice was on backwards.

IRWIN The vice was on backwards? I believe they can only go on one way.

SCOTT That's right, there's only one way they can go on, and it was loaded backwards.

IRWIN Oh, you mean it was assembled backwards?

SCOTT Sure was.

IRWIN You put it on the right way, and it was backwards.

SCOTT If we could have had that equipment a little earlier, we could probably have learned a lot of those things.

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Contingency EVA training. KC-135, WIF, and one-g walkthroughs. Our contingency training we did in the WIF. We did it shirt-sleeve at the Cape. I think it was adequate. Once you run through it, you find out that it works well, that the procedures are well developed, and you need to do it one time.

WORDEN I thought the training program for the EVA was just right. There wasn't too much. I thought there was an adequate amount of training. The sessions in the WIF could have been reduced somewhat because the sensation of neutral buoyancy is sufficiently removed from zero-g that with too much training in the WIF, it almost turns out to be negative training. The operation is so much more difficult in the WIF than it is in flight or in the zero-g airplane that fewer sessions in the WIF would have been in order. Maybe one or two sessions in the WIF, instead of a large number of them, would be perfectly adequate. The zero-g airplane was invaluable. The one-g trainer going through the prep and the post was completely adequate. I thought that particular training program was outstanding.

SCOTT EMU familiarization and chamber training. We could have honestly done with one more EMU session before we went, particularly on the PLSS.

IRWIN They wanted to brief us on it, we just didn't have time to fit it in.

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SCOTT During the last couple of months, you should have one more run through on that. We have no simulator for the PLSS at all. All we have is the chamber run, so we never really go through the malfunction procedures in any simulator. I would recommend, during the last couple months, to sit down and go through all the PLSS, particularly the malfunctions, to make sure that the malfunctions included in the cuff checklist are thoroughly understood. The chamber training was good.

Mockups and stowage training equipment.

WORDEN I thought that was the best stowage I've seen in a simulator at the Cape. My only complaint about it is that it had to be shuffled from one simulator to the other.

SCOTT On the LM side — the mock-up at the Cape was a little slow coming up to speed. When we left here and went to the Cape, we stepped down as far as high fidelity in the mock-up. I didn't think the one at the Cape was quite up to speed when we got there, but it came around. Other than the lack of flight configuration on the mock-up on the training equipment down there, it went pretty good.

Photography and camera training equipment. That was available, and we utilized it. We had a rather slow response on the film, I thought, particularly when we were trying to work out the

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SCOTT (CONT'D) surface 16-millimeter procedures. With new procedures and trying to get the Rover and everything — I thought the response on getting film developed was very slow, until the last couple of weeks. Then it was very fast, but we could have sure used a little earlier evaluation of some of that.

SLAYTON Did you have any problem getting the film exposed at the Cape?

SCOTT No. We just didn't get it developed.

SLAYTON You didn't have any camera problems at the Cape like you had in flight?

SCOTT No, as a matter of fact, the camera at the Cape worked fine. We got some great film that we took down at the Cape. The film worked fine at the Cape, and it didn't work in flight at all. I don't know what the answer to that is. Except we had one mag, I guess, that worked on the surface pretty well. The Hasselblads that we used on our field trips in the training at the Cape worked well for the most part. We had some failures during the training, but it sort of prepared us for the failures during flight.

Lunar surface experiment training. Our ALSEP training at the Cape went well. We had trouble with the pits in which we drilled holes, but I think they finally got that straightened

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SCOTT out. I thought the ALSEP here itself was pretty good. It
(CONT'D) was good training.

IRWIN It sure was.

SCOTT There again I think the suited exercises were the valuable ones.

Lunar landing — LLTV. All I can say is that that's the absolute answer to learning how to land on the Moon. I was very comfortable during the final approach phase. We did it just like we planned to do it — went manual at 400 feet. I felt a little more positive than in the LLTV. The LM was a little more responsive. I put it just the way I wanted to put it, no problem. The reason I was comfortable was because I was comfortable in the LLTV. That machine is excellent. The support out there is superb, and it is an absolute requirement.

The LLTVS is a good simulator for procedures, and I think everybody understands how to use that. The LMS has its role also. I think that the L&A is excellent for giving you visual cues, except for our problem of having too much relief. The system itself is good.

Within the LMS you have a delay in the manual throttle, which at times, I feel, is negative training. They're looking at it. I think that they are going to try and see if they couldn't put some sort of circuit in there to take the delay out.

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SCOTT
(CONT'D)

Apparently, the ACA has some sort of circuit in it to eliminate the delay between the command and response. If they could do that with the manual throttle, I think that would make the LMS much better. The manual throttle practice I got in the LMS was negative training for the manual throttle I had in the LLTV. It's too bad Jim didn't get a chance to fly the LLTV.

IRWIN

I didn't need it.

SCOTT

Planning of training and training program. I thought it went along pretty well. Mike, I think you did a good job. I think you kept up with us.

WORDEN

I think Mike did a superhuman job.

SCOTT

I think the schedule went along pretty well. I don't think we had too many changes. Once Mike got a weekly schedule out, it worked very well. I don't remember having any big glitches. Occasionally we had some little changes, but I thought the training plan went along pretty good.

IRWIN

It worked very good.

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18.0 CSM SYSTEMS OPERATIONS

IRWIN We sure get a lot of confidence in the SM RCS and the DAP as you go along, because it all works so smoothly. The EPS worked very good.

WORDEN Jim, comment on that gimbal motor transient. When the gimbal motors are turned on, the voltage drops only a half a volt whereas in the simulator, it frequently drops 2 to 3 volts. That was the only difference that I noted.

IRWIN Okay, ECS. I think we've talked about our problems there relative to the water supply system.

WORDEN The only thing we didn't cover in that area was the differences in the quantity reading of the potable water as we got closer to entry. We had a blockage in the potable water supply. The potable water tank seemed to be going down at the same time the waste tank was going up, which certainly doesn't correspond to the way the system operates.

IRWIN I think they called us and told us we had a blockage in the potable water. But, they felt like we had enough water to finish the mission, which was like 80 percent with a few hours to go. They did call us and tell us that. So, I guess they've got a handle on whatever the problem was.

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WORDEN Either that, or the sensor wasn't working right.

SCOTT Waste management - The urine management was a chore, but it worked okay. Having to go into bags and then dump overboard took a little bit of time, but it wasn't any real problem. Those bags seemed to work okay, and the big filter worked okay. I think that's an acceptable mode. It just adds one more housekeeping chore during the day. The canisters worked all right.

Telecommunications - I see nothing off-nominal there. Everything seemed to work as per the Flight Plan. Mechanical, tunnel, struts, probe, hatches - all worked very well.

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19.0 LUNAR MODULE SYSTEMS OPERATIONS

19.1 PGNS

SCOTT Lunar module systems operations. We can go right straight down Section 19 here and talk about the PGNS first. I thought the PGNS was fine inertially. The only question I have is that I don't understand why we got the PIPA BIAS updates prior to descent: Optically, the AOT worked very well. No problems. Rendezvous radar worked very well, with no problems except for not getting our lockon during ascent. We did not expect to have the dish drift. We thought that was a unique problem of 14's. Our understanding prior to going on the flight was that it would not drift and we would get a good lockon during ascent. We got new numbers to load prior to the ascent for positioning. I never got a lockon. I attempted to manually slew it 4 seconds up, 4 seconds down, 4 right, and 4 left and I got no indication of signal strength at all. I don't understand that. Landing radar worked very well. We got altitude velocity lights out right away after we yawed around on the descent and, as far as we know, we got good data all the way. The computer worked very well — no unexplained alarms. We had an uplink and downlink too fast alarm when we initially powered up. I think that was inconsequential. Controls and displays were as advertised. Procedural data was as advertised.

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SCOTT I think all the procedures were excellent. Great guidance
(CONT'D) system.

19.2 AGS

IRWIN As for modes of the operation, I guess you checked it out -
the attitude hold function.

SCOTT Yes, that was very good.

IRWIN I did pulse also; it works better in flight than the simulator,
I think. We have heard that from previous crews; it was more
positive. Initialization went just like it was supposed to.
CALS worked great and were within limits every time. Rendez-
vous radar navigation: we used the automatic updating during
the rendezvous, you checked out the needles, and they agreed
with the PGNS.

SCOTT I might add, as far as the overall system there is concerned,
that the rendezvous with the new programs in both computers just
worked. I couldn't ask for any more. We got into orbit. I
had a visual on the command module and pointed a COAS setting.
The radar needles were nulled, the PGNS needles were a little
off, and the AGS needles, as I remember, were almost null.
That had everything lined up, and it was going to work. So
we pressed on.

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IRWIN Engine commands, I suppose, were there. Ground can confirm that. The electronics: I suppose there must have been a glitch to give us the AGS warning light. It occurred about at insertion time. For some reason, they told us to trim AGS residuals at insertion rather than PGNS. You commented that we could not get it below 2 ft/sec.

SCOTT I think we have seen that in the simulator, too. It wasn't a surprise to me because we had seen it in the simulator. I don't think we ever had a good explanation. I remember asking after some of the SIMs, and they said they would check it. We can get into that in the rendezvous part.

IRWIN Burn programs worked well. Controls and displays were good. As for that AGS warning light, when it came on I immediately reset it. I checked the AGS self test. It looked correct. I immediately got a call from the ground that the AGS looked good to them, so we continued as normal. AGS solutions were very, very close to the PGNS, command module, during the rendezvous.

SCOTT Controls and displays: I might comment that during descent and ascent both checked — the FDAI on the left side relative to PGNS and the AGS — and they always had good agreement. There was only a slight jump in the attitude. I think the alinements were very good and they held very well.

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19.3 PROPULSION SYSTEM

SCOTT I have no comment on propulsion system descent and ascent.
It worked exactly like it was supposed to work. Smooth burns.
One question we had before descent was whether we would feel the ullage. I felt it. Didn't you?

IRWIN Yes.

SCOTT There is no question that we had ullage when we started descent.
The ascent propulsion system was very smooth. It felt as if we came off on a spring when we left the descent stage. It is just a real smooth, quiet ride.

19.4 REACTION CONTROL SYSTEM

SCOTT Very positive attitude control. Somehow or another, we drifted off attitude during the SIM bay inspection on the command module, or else the command module attitude was different.
I am not sure exactly which. We stayed in a tight deadband attitude hold, and the command module did a maneuver to the SIM bay inspection attitude. Then he maneuvered back to his original attitude. We were no longer looking at him. We had about a 90-degree maneuver to do and I am not sure I understand that. I don't understand that one, but as far as RCS is concerned, it worked just fine. No problems.

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SCOTT Translational control was as advertised. Normal. How about
(CONT'D) electrical, Jim?

IRWIN On the RCS, you commented we saw some pulses there on ascent
 feeding.

SCOTT Yes, the oxygen, the oxidizer manifold readout, was pulsing
 during ascent feed. I don't know why.

 Didn't we end up at the terminal phase there of braking with
 something like 80 percent a side left on RCS?

19.5 ELECTRICAL POWER SYSTEM

IRWIN As far as the electrical system is concerned, I did not see
 anything that was off nominal.

19.6 ENVIRONMENTAL CONTROL SYSTEM

SCOTT Lighting was fine. We talked about the one anomaly we saw in
 the ECS prior to a separation.

IRWIN We just used LCG cooling for a short period there before we
 went on the PLSS.

SCOTT And it was cool.

IRWIN After EVA 3, when we knew we had a lot of consumables left,
 we used it. Water supply: we were short on that because of

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IRWIN (CONT'D) the 25-pound leak. Let me drop back to the lighting for a moment. We never really needed the utility lights. In fact, we disconnected them and took them out, when on the surface, to get them out of the way.

SCOTT I could have used them during the rendezvous. I missed them. I missed having mine during the rendezvous.

IRWIN You should have mentioned it. I would have put it on.

SCOTT It was not really necessary. We were going along pretty well. I could have gone back and gotten it. I still think they are useful. I got used to using mine.

IRWIN The water glycol was nominal. That's all on ECS.

19.7 TELECOMMUNICATIONS

IRWIN We both noted the noise associated with the yaw drive on the antenna.

At one point, we thought the command module was firing jets.

SCOTT Yes we surely did. It sounded just like RCS thruster activity.

IRWIN Really noisy. It seemed as if it almost smoothed out toward the later part of the flight. We didn't hear it. I don't know whether it actually changed or we got used to it. VHF worked well. EVA antenna was okay.

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SCOTT A comment on the VHF with the command module: we had very broken communications until the command module came up over the mountains. When the CM normal line of sight was obscured by the mountains, we did not hear him until he came over the mountains. It was no real problem, but something to be aware of.

That gets us through the IM systems. When everything works that well, there is not much to talk about.

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20.0 LRV OPERATIONS

SCOTT I think the manual deployment system is excellent. All the cues are good and I had a good understanding of how it works. It looks very reliable. The procedures are good. The Rover setup worked all right. Mounting and dismounting was an interesting operation. I found the best way for me to get into the Rover was to sort of back into it, get myself positioned relative to the seat, and then give a little hop while holding on to the low gain antenna mounting staff, and sort of pull myself as I went up into the air and back into the Rover. It didn't take a very big hop, just enough to get off the ground. Then I'd swing my feet over the footrest, grab the seatbelt, pull it across, and attempt to get it attached. I had a fair amount of trouble getting the seatbelt hooked onto the rail, not because it wouldn't hook, but because it was hard to find the rail in a relative position. As a recommendation, I think we ought to have a bar-type affair like in the carnivals — a little kiddie bar — which we suggested prior to the flight, but I guess there was a weight problem. In retrospect, the weight penalty would far exceed the problems associated with the seatbelt. I think a bar which configures to the suit, which can be moved forward against the console when you want to get out and which just folds back

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SCOTT
(CONT'D)

and is locked into detent once you get in the Rover, would save considerable time and effort.

IRWIN

I used the same technique that you just mentioned. I grabbed the staff of the sequence camera, gave a little hop, and tried to slide back. Maybe it's because my legs aren't quite as long, but it seemed as if I never did get back far enough in the seat when I used that technique.

SCOTT

Yes, I noticed that. When I was standing to the side of you, you seemed to lean back too far. Maybe that's because your legs were as far as they could be, and that footrest needed to be pulled back further so you could get your back straight up. When you contacted the seat, you were leaning back too far, and the PLSS was at an angle to the backrest on the seat.

IRWIN

Yes. Initially, we had the tool installed on the right side, and I was hanging up on that, both getting on and getting off. I took that off and it seemed to work a little better, I never did get really comfortable at all in getting on and off. Of course, my seatbelt was let out all the way, and I still could not collapse the suit sufficiently to lock myself in. Dave had to come over every time and get my seatbelt. In getting off, I could strain against the seatbelt and collapse the suit sufficiently to release myself, but I just could not lock

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IRWIN myself in, which added several minutes to each stop. It was
(CONT'D) unfortunate. I heartily endorse the suggestion Dave has for
 a bar there rather than a belt.

SCOTT As a matter of fact, that was your idea about 6 months ago.

IRWIN Yes.

SCOTT Okay. Vehicle characteristics. Unfortunately we didn't get any
 16-millimeter of the vehicle, but I'll go through a little dis-
 cussion of the driving. In general, the hand controller works
 very well. During the first EVA, we had front steering which was
 inoperative, and the front wheels were apparently locked in the
 center position. This resulted in some difficulty in steering
 in that a sharp turn would cause the front wheels to dig and
 the rear wheels to break out. It was difficult maneuvering
 the vehicle and we did lose some driving speed, because I
 couldn't turn it sharp without having the rear wheels break
 out. I might discuss what we did there to correct that prob-
 lem. At the beginning of the second EVA, the ground requested
 that we cycle the steering switch again, which I had done
 during the first EVA a number of times. Upon cycling it, the
 steering worked fine. I have no explanation for the difference
 between EVA numbers 1 and 2, other than the fact that Boeing
 must have sent somebody in there during the night and fixed it.

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CONFIDENTIALSCOTT
(CONT'D)

The double Ackerman steering was too sensitive for the higher speeds — 10 to 12 kilometers per hour. I think that the max speed we got was like 13. The double Ackerman was too sensitive. Even with the seatbelts fastened, there's a lot of feedback into the hand controller. I think with a more secure attachment to the vehicle, such as a bar that keeps the man firmly attached to the seat, there would be less feedback into the hand controller. Then the double Ackerman would be not quite so overly sensitive.

I did attempt to turn off the rear steering with the switch, because I felt that the front steering alone would probably be optimum. I still do. Unfortunately, when I turned off the steering, the rear wheels wouldn't center. They would drift to one side or the other and we'd be in a crab. We could have disengaged the rear steering, but I decided not to fool with it and try something new. I'd leave all the steering as it was and accept double Ackerman, because that was adequate.

The driving was quite easy when we were on flat terrain which didn't have too much in the way of obstacles. When we ran across the crater fields which had a higher density of small craters, anywhere from a meter to 2 meters across. (All the craters had very low rims so they weren't too prominent until

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SCOTT
(CONT'D)

you got right up on them.) But these smaller craters presented some pretty tricky obstacles at higher rates. So, we had to slow down. I didn't feel comfortable driving through some of the craters greater than 6 to 7 kilometers an hour. I'm sure the Rover would have handled it. We bottomed out on the suspension maybe three or four times during the whole trip, and it seemed to hold very well. But I just didn't feel comfortable bottoming out the suspension, and I tried to avoid all the craters which would produce that kind of response. In doing that, it took a fair amount of time and quite an attention to the traverse in the direction which we were going.

I think the wire wheels worked very well relative to traction. The only wheel slippage that we noted occurred in hard turns at high rates where the momentum of the vehicle would keep it going straight until the speed slowed enough for the wheels to catch. One time we had the wheels spinning in the soil; they were digging in in opposition.

IRWIN When we got to the ALSEP site.

SCOTT Yes. As I remember, we picked it up and moved it to another spot and it worked fine. Did we just pull it out?

IRWIN We just went in reverse.

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SCOTT That's right. I think the wire wheels are excellent. The bearing of the wheels on the surface must be very light, because the vehicle took us up the slope of Hadley Delta at 10 kilometers an hour. I would guess we were 20 degrees on that slope, wouldn't you?

IRWIN Yes. I think it was probably 20 degrees.

SCOTT It went right up there without any trouble at all. When we got off the vehicle, we noted our boots sank in the soft soil a half an inch or so, maybe more. The Rover tracks just made a very slight surface disturbance.

IRWIN I'd estimate we sank (boots) in maybe 3 inches.

SCOTT It was really deep there, wasn't it? The wire wheels are excellent. They picked up very little dust. We did have an accumulation coming up under the fenders. I think the fenders are well designed and quite adequate. It seems to keep the dust off pretty well. You had a chance to see if there was a rooster tail behind the Rover when I drove. Did you see much?

IRWIN One time I did comment on the rooster tail. I guess it was on the Grand Prix.

SCOTT How much was it?

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IRWIN It kicked up, I'd estimate, 15 feet in the air. We had one over your head and it impacted in front of you.

SCOTT Did it really?

IRWIN Yes.

SCOTT I didn't notice it looking forward.

IRWIN It was really impressive. It's too bad that sequence camera didn't operate.

SCOTT I didn't notice, when we were driving at the higher rates, any dust or dirt coming forward into our view.

IRWIN I think at that particular time, you were just doing a max acceleration, and that's when it kicked up the rooster tail.

SCOTT Auto max acceleration. I don't remember at any time feeling a particular wheel slippage. I think the vehicle accelerates very well, probably as we expected and very similar to the centrifuge runs we had under one-sixth g simulation. The breaking is more responsive than I expected. When I did that little Grand Prix exercise and put the brakes full on, it came to a stop I would say comparable to the one-g trainer. I expected to slide more. The braking was excellent.

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SCOTT
(CONT'D) You have to be quite careful at high velocities that you don't turn too quickly, because the rear end will just break out immediately and you'll go sideways. However, in our testing of side-vehicle motion, there was no tendency for the vehicle to tip over. I thought it was very stable in side slippage, didn't you?

IRWIN I guess there was only one time when I had some reservations; I thought we might flip over. Seemed like we went up to about 30 degrees on a roll.

SCOTT I don't think it was that much, but maybe so.

IRWIN It felt like it.

SCOTT You were on the downhill side.

IRWIN That's true.

SCOTT My feeling was that it's a very stable vehicle; the CG is very low. No tendency to turn over. I think you have to slow down when you need to make a sharp turn. If you just pay attention to the surface in front of you, you can control things and make quite good time. I haven't seen the average Rover speed yet, but I was quite pleased with the velocity we could make traveling across the surface. It was more than we expected. I think our last numbers before flight on the LRV trainer were

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SCOTT
(CONT'D)

9.3 kilometers an hour, and as we mentioned, we got up to 13. We could maintain, over most of the terrain, a steady pace of 10 or 11. The 13 was with the throttle full throttle, the 10 or 11 was backing off somewhat. It was easy to position the throttle in one position, or to position it at some throttle setting to keep a constant speed, and steer merely by putting small inputs left or right until you got the turn you needed, and then releasing it for recentering the steering.

I had no problem with fatigue in my arm. I had no problem seeing forward because of the suit. It handled quite well, as far as controllability in the suit.

It was far more difficult to come down the slope than it was to go up. We approached the down grade very cautiously so it wouldn't get out of hand. On one slope, once we got off the Rover, it had a tendency to slide down the hill sideways. So, we took turns holding it, so it wouldn't depart. It rests so lightly on the ground. Once we got on it though, it was quite stable.

IRWIN

It really seemed to require both of us on it for stability. You wouldn't let me walk down. You wanted me to get on.

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SCOTT Yes. I felt much more secure if we were both on there to keep it firmly on the ground. It's just very, very light when it's by itself.

IRWIN One time we did a 180; the back wheels just broke loose and they slid around.

SCOTT Coming down the hill?

IRWIN Yes.

SCOTT I think that was just because of the slope. We probably had most of the weight on the front wheels, and I had to make a turn to avoid a crater. There just wasn't much traction on the rear wheels. It was just a matter of going slow when you had obstacles, and catching up on your rate when you had a smooth field in front of you. I couldn't ask any more in controllability of the vehicle. It's just superb. I have no recommendations on any changes in the control system. The reverse switch works fine. The techniques we were taught in how to go into reverse and how to go into forward worked fine. We did use reverse several times. Aside from the fact that you can't see behind you — when you can tell me which way was clear behind me — I was very comfortable backing up. Like the time at the ALSEP site — there was no problem.

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IRWIN We eliminated the Velcro on the seat. I wonder, in retrospect, whether it might have been a good idea to have that there. Maybe give you a little more support, particularly if you went to a bar arrangement rather than a belt. You might want to reconsider the Velcro on that.

SCOTT Yes. I think it would be a function of how hard it would be to disengage the Velcro getting off. Also, when you get back on, we sort of shuffled around there. We wiggled into position. With that Velcro back there, you couldn't do it. I'd say you're better off without it. You should get a more secure bar-type arrangement to keep you in the seat. I'm afraid with Velcro you'd get stuck to the back in a position which was uncomfortable, or difficult to utilize the throttle. Many times I had to shuffle my position so I could reach the throttle and to be comfortable. I'd get in, and I'd feel like I was in the right spot, I'd reach over and I really didn't feel comfortable on the hand control. I'd vote for no Velcro myself.

IRWIN As far as coming downslope, I felt more comfortable just holding on rather than being secured by the safety belt. In case there was any chance of going over, I think it's better that one man be unstrapped so he could help turn it over.

SCOTT I don't think it would turn over. I think it would have more tendency to turn over if you fell off. If it started to go

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SCOTT
(CONT'D)

and you came off of it, I think it would have more tendency to go over because the CG would be all on one side. If both people stay on and if you drive it reasonably, I don't think there's any tendency at all for the thing to turn over.

IRWIN

If it did flip over with both guys strapped in, I don't know whether they could release themselves.

SCOTT

With the seatbelts, yes. But if you had those bars on there, you could release yourself. Maybe there's an honest difference of opinion here. I didn't ever feel like we would turn over. And if we had turned over, I didn't feel like we were going to get pinned.

IRWIN

I think you probably have a better feel for it since you were driving it. You could feel, it's like flying an airplane. You know what it's doing all the time.

SCOTT

Yes. That's right. That's probably the same kind of thing.

IRWIN

I had excellent visibility. I could turn my head and I could look back from 8 o'clock around to the 4 o'clock position. One time you commented that we were getting some reflection from the mirror on to the TV.

SCOTT

Yes. We agreed before the flight to point the TV aft and down during the driving. At one point there it picked up the Sun.

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SCOTT
(CONT'D)

The mirror on the TV picked up the Sun and put it right in my eyes. That was pretty bright, but no real problem.

During EVA-2, you put your visor partially down, the hard, opaque, outer visor. It helped you, and you suggested I do that. I put mine down, and it really helped, particularly driving up-Sun. You can drive right straight into the Sun with that visor down. You probably have better ground visibility than when you're going cross-Sun. But with the visor up, it's pretty tough going driving into the Sun.

IRWIN

After EVA-1, I had a headache because of the glare. On the second EVA, I pulled the glare shield down to protect my eyes and I felt good from then on.

SCOTT

Yes. That was a good suggestion.

Once I got the suit attached to the Rover I felt pretty secure. Suspension was excellent. I'd be interested to know more about bottoming out of the suspension. Maybe that's no problem. I felt uncomfortable when we did bottom the suspension. We went over one rock, must have been a 1-foot boulder, one wheel went right smack over it. I was trying to avoid a crater. I missed the crater and picked off the rock, and it bottomed out as we went over it, but I didn't feel anything else.

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IRWIN It was an angular, very angular rock as I recall.

Yes. I thought sure we'd tear up the chevrons.

SCOTT Did not hurt a thing apparently.

IRWIN I never got a chance to check the chevrons for any damage.

Did you?

SCOTT No. But, even though the wheel bottomed out, I think the chassis stayed pretty level. It was very similar to the one-sixth g operation that we ran here in the centrifuge, as far as the bed or the chassis itself. It seemed to remain fairly stable, whereas the independent suspension on each wheel was doing all the work. Lower damping than we had here. We were bouncing more because we were lighter (compared to the centrifuge).

Systems operations. I thought the nav system worked extremely well. I don't think we had to make an update the whole time.

Yes, we did one time. Was it at the rille?

IRWIN Yes. There was one on EVA-1 when we were down at St. George. I thought there was one, also, when we were up on Hadley Delta on EVA-2.

SCOTT Maybe you're right. Well, that's in the data.

IRWIN Yes.

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SCOTT But, it was no problem. The technique is simple, straightforward. There was one, the ground planned it ahead. They said, "Hey park it down-Sun, give us your reading. When you get back on, we'll give you the update." That was good thinking on their part. The only comment I have about the nav system is: On both trips to the front, I felt that it was pointing us too far to the right of the LM. The bearing was such that it would have taken us to the east of the LM. I commented on that, I think, on EVA-3. As we were going back to the LM, I was going to bias myself a little bit to the left of the LM. But, it turned out that the bearing on EVA-3 was right straight to home plate. When we came up over that rise, by golly, it was pointing exactly to the LM. I think that nav system is just excellent. It gave us a good reference as to where we were. We used that quite a bit, our bearing and distance from the LM. That was a great help in positioning ourselves. I didn't feel like we were ever in any question about our location relative to the LM. Did you?

IRWIN No. It was a good aid for the ground also to track us, where we were, and assist us in some cases to expect certain craters coming up.

SCOTT Yes.

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SCOTT
(CONT'D) The batteries. I guess the ground has better data than we do on that. I noticed the - the amperage readout was always lower than expected. It was never working as hard as people thought it would.

IRWIN Yes. And the amp-hours sure stayed high too, all the way through. I had some difficulty reading the number 2 readout on the battery. I had to really strain to see that from my position because I was riding so high.

SCOTT I never tried reading the gages on your side because you always did that.

TV and TCU. We had to help the TV camera there several times when it got hung up pointing up and pointing down. But other than that, I thought it worked quite well. The ground thinks it works extremely well. No problem, if we could square away the antenna pointing device. There's no problem selecting the modes and turning the TV on.

IRWIN You might want to comment on the cable you had to secure with the tape. Maybe that should be a design fix?

SCOTT Yes. I think they could put a clip somewhere. The clip could be right down there on the high gain antenna where we put the tape. We put the tape in a position which we had discussed prior to the flight, anyway. We talked about putting the

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SCOTT (CONT'D) high gain antenna cable around the little loop down there where the shaft comes out when you unstow it. That's where we taped it. Once we got that taped, the problems associated with hanging up on the cables cleared up.

The LCRU battery was fine. Electrical-mechanical connections all worked well. Dust generated by the wheels — we'd have to say that the dust was minimum. We did have to dust off the mirrors quite a bit, but it was far less than I expected to see.

IRWIN Yes. I don't know whether all that dust was created by the wheels. It could have been the dust created by us just getting on and off because we kicked a lot of dust, you know.

SCOTT Yes, that's right.

I really didn't see much dust going forward from the wheels. I could see it hitting the fenders, and it seemed like the fenders did very well. I really didn't see anything going forward.

IRWIN No. That's why I had difficulty accounting for the dust that was on the mirrors.

SCOTT Yes. Except it could have been very fine over a long period of time that we couldn't see. The dust accumulation was minimum. It was fine dust. The little decal with the

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SCOTT
(CONT'D) procedures, just forward of the hand controller, was almost completely covered most of the time. If I used it, I had to brush it off.

IRWIN There was one mirror that was broken on the TV camera. Cracked. One of the small squares was cracked. I don't know when that occurred.

SCOTT It wasn't there when we started. I don't remember seeing that when I put the camera on.

Okay. Payload stowage, I think we have plenty. We never did get everything filled up. I think if you want to go out and make a survey of large rocks and put them under the seat pan, that would work just fine. Because of dust accumulation, I'd recommend those seat bags have a cover on them. Beta bags underneath the seat pan, some firmer cover, because my seat bag got full of dust. I'm glad we had the flaps that stowed over the film mags and the 500-mm, otherwise it would have just been thoroughly dust covered. I'm afraid we would have run into the same trouble as you did with your camera, with all that dust in there. Because almost every time I got under the seat pan, there was almost a solid layer of dust over it.

IRWIN Yes. And there was plenty of room in my seat pan to stow a lot of rocks. On EVA-3 we picked up a lot of rocks that we

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IRWIN just left on the floor pan. We did not put them under the
(CONT'D) seat. We drove back with them in that position.

SCOTT Did we lose any?

IRWIN No, we did not lose any.

SCOTT That's interesting.

IRWIN Your seatbelt was hanging up on that screw.

SCOTT That's right.

It was a Cannon plug down beneath the console on my side, ~~DOWN~~ that we had never seen before. I guess the one-g trainer just doesn't have it. My seatbelt kept hanging up on that. I'd get on and reach for the seatbelt, it'd hang up there and I'd have to get all the way back off and disconnect it and get back on again. There again, let's eliminate the seatbelt and put a bar in. That will solve that problem.

IRWIN On the initial deployment of the seats on the Rover, I was surprised that it was so hard to disengage the Velcro.

SCOTT Yes, it sure was.

IRWIN It took a couple of extra minutes to pull that loose.

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SCOTT Yes. And the Velcro on the seat bag under my side, there's far too much Velcro for those flaps. It was there in order to hold the seatbelt in during launch. If we eliminate the seatbelt, we can eliminate all that Velcro.

In general, the Rover provided us the capability to go places we never would have been able to go on foot. It was an excellent device, with the exception of the recommendations on the seatbelts. I can't think of anything that could be improved. Do you?

IRWIN Yes. On the map case. That wasn't really an optimum position, because I was sitting up so high that I really had to strain to get to the maps. For that reason, I always just stuck with one map — the 1-to-25 000 scale. So I just had one map to use, always just held it in one hand. I think some improvements could be made in that area.

SCOTT That's a good point.

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21.0 EMU SYSTEMS

SCOTT PGA FIT AND OPERATIONS. I ended up with a compromise solution on my arm length and my gloves. I had requested, just prior to the flight, for the people to shorten the arms so I could have mobility close to my chest, where I had to do most of the work. If the arms were too long and the fingers were extended at that point, I got hand cramps trying to work the gloves. If the arms were shortened, when my arm was outstretched my fingers were pushing against the inside tips of the gloves. My feeling before the flight was that I'd rather have the tight arms than the cramps in the hands. It resulted in too much pressure on my fingertips, but I'll accept that compromise because it enabled me to continue working without any hand cramps. I never got any hand cramps at all throughout the whole operation. I felt like I had good mobility in cinching up the geology sample bags and in doing all that ALSEP operation. Driving the Rover was also quite comfortable, except for my fingertips. Other than that, I thought the PGA was excellent.

IRWIN I think I had the same fit that you did on EVA-1, certainly. At the end of the EVA, my fingers were really sore — the fingernails and the end of the fingers. After that, I cut

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IRWIN (CONT'D) my fingernails back to the quick, just as far as I possibly could with the scissors; and then on EVA-2, my fingers didn't bother me at all. That solved it for me. I didn't have any cramps either.

SCOTT We had both experienced cramps in training. As a matter of fact, I think when we first started at the Cape, 3 or 4 hours after we'd gone out on the rockpile, we were sitting in debriefing at the CMS and both of us cramped up. You become immobile when your hands get cramped, there's nothing you can do.

IRWIN They say that is due to a loss of potassium from profuse sweating. I don't think I was sweating at all, except that during EVA-3, I was a little warm. But the fact that we were not sweating, I think, probably helped us.

SCOTT That's a good thought.

We've discussed the suiting and unsuiting. BIOMED INSTRUMENTATION. We've discussed that. I felt LCG was excellent. I think the MIN, INTERMEDIATE, and MAX COOLING positions were just right. I used all three periodically. I used MAX COOLING, particularly after we had sublimator startup on the AUX tank. Because usually, when we got to the AUX tank and went to

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SCOTT (CONT'D) MIN COOLING, by the time we got the sublimator going, I'd gotten fairly warm. I went to MAX COOLING and that cooled me right away. I think that LCG is going to be one of the significant milestones in the program. That is just really great.

IRWIN Yes. It's great. I never did use MAX COOLING.

SCOTT Never did?

IRWIN Never did. INTERMEDIATE was the most I ever used.

SCOTT You didn't have to drill.

IRWIN That's right.

SCOTT Let's see, HELMET. No comment. Just fine. The visors are all good. They were all useful and it worked. LEVA operation was good. GLOVES, we discussed those. I surely think that a better glove could be made which fits tighter. I think the gloves, in my case, are still too bulky, and there is too much easement inside the glove. I think for an EVA operation you need to have a glove which has a smaller easement than for an IV operation when you don't plan to pressurize. When you plan to run pressurized all the time, as you do an EVA glove, I think they should be designed and built for that operation

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SCOTT alone, and not try to compromise by having it comfortable in
(CONT'D) an IV situation.

IRWIN I think the wrist ring got to me more than the fingertips.
It cut into my right arm across here. Maybe that was a function of my operations. It might have aggravated that. It probably would have paid off in this situation to use a wrist glove, at least on the right arm. Particularly after the first EVA, I noticed it was starting to go raw.

SCOTT UCTA OPERATION. No comment. Jim, would you like to comment on that?

IRWIN Well, I used mine quite frequently. Unfortunately, on the first EVA I must not have had a good connection, because it all leaked out in the suit. The LM system took care of any urine smell. I never smelled it once we got back in the LM.

SCOTT I didn't either. And I guess your suit was dry the next day, wasn't it?

IRWIN Yes.

SCOTT Yes. I think that suit drying operation is a good one.

The EMU MAINTENANCE KIT. The new antifog application works great. It was very simple and straightforward. Never had

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SCOTT (CONT'D) any fogging at all. I guess we wouldn't expect any without it, because the flow is pretty good.

IRWIN We used the lubricant out of the bag. We never used the replacement seals or the rings, never had to.

SCOTT DRINK BAG. We talked about that. The ANTIFOG. PLSS PGA OPERATIONS. Everything connected and disconnected all right, except when we got the dust and dirt. Then, sometimes, it would stick, but in general, I thought it worked great.

IRWIN Well, your comment, you know. Your's was riding kind of loose at the end of EVA-3. I thought mine was riding higher than it should. Perhaps because of the adjustment of the straps. Also, the connection of the RCU to the PLSS, particularly on yours, was galled on the surface. It was galled, which made it rather difficult to secure.

SCOTT The electrical connections? That's right. You mentioned that right away. The first time you put it on you said it was all galled.

IRWIN I'm surprised that it would go through inspection.

SCOTT Pressurization and ventilation were excellent. Liquid cooling and circulation was excellent. Communications were superb,

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SCOTT (CONT'D) except for your antenna. There was another one that I can't believe ever got launched that way. That was about as gross a mess as I think I've ever seen. Connectors and controls, I thought, all worked very well. I think it was a good idea that they put that plastic plate over the flags in the RCU, because that sure got dirty.

IRWIN I had some difficulty seeing my flags with the visor down.

SCOTT I did too. I found that it was the dust accumulation.

IRWIN I had to actually strain against putting my nose against the visor to look down and see the flags. I guess, also, I felt that when I was getting out of the LM when it was in the shade, I preferred to have the visor up so I could see better. Then I put the visor down after I got out.

SCOTT I did the same thing. As a matter of fact, with the visor down in the shade, you couldn't see at all.

RCU. I think the new RCU attachment to the PLSS straps bracket is a good secure one. The RCU won't come off, but it's sort of hard to get on. I don't know what you can do about it.

IRWIN I thought we got to the point where we were getting on pretty well.

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SCOTT I always had to struggle. We got it on pretty well, relatively. There's not much you can do about that. It's certainly better the way it is now than it was before, because it won't come off once you get it on.

I thought the OPS worked fine.

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22.0 FLIGHT EQUIPMENT

WORDEN We ended up without a mission event timer in the LEB. The digital event timer on the main panel — the SECONDS window was obscured. It gradually got worse right from the very start of the flight. It was okay when we first started, and then about half way through the flight the units on the SECONDS window just couldn't be seen. All you could see was the 10-second pulse; you could see that number clicking. But the SECONDS window was completely gone.

SCOTT Crew compartment configuration — the big stowage boxes are too big. They ought to be partitioned because everything comes out every time you open the door.

WORDEN I think those mirrors are terrible. They are hard to manipulate. You can never get them in the right location. I had the distinct impression I was going to break them several times. I used those mirrors for some of the photography in window number 4, such as the solar corona, and that required getting different settings, particularly the Hasselblad. I used the mirror to look at the settings because they are on the outside. Those particular settings are on the outboard side of the camera. I had to use that mirror to look at those settings. That really irritated me — trying to get those mirrors turned around.

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SCOTT IV clothing and related equipment — We were wearing the CWGs quite a bit in lunar orbit because of the temperature in the cabin. We suggested maybe putting pockets on the CWGs so you can keep track of your pencils and scissors.

WORDEN We had a total of five sets of coveralls onboard — the three that we started out with, and then there was a clean set for Dave and Jim.

SCOTT That was in the LM.

WORDEN Right. To put on while you were docking. There is nothing quite as refreshing as putting on a clean set of clothes. We ought to consider putting another coverall onboard for the CMP. He wears the coverall more than anybody else.

IRWIN We had a problem with the wide strut lock.

WORDEN Yes. That was an internal problem. I wasn't expecting that first detent to be as heavy as it was. After Dave pushed it into lock, it was pretty obvious to me that it was my own fault and my own problem.

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23.0 FLIGHT DATA FILE

SCOTT The checklists Launch and Entry, the Updates, and the Cue Cards were very good. I was pretty happy with the overall Flight Data File. I think it was very timely and very accurate. I don't think we found any mistakes in it during the flight. Towards the end of the flight, especially when we got into EVA, we had a lot of confidence that we didn't before we went. There were a minimum number of changes at the last minute, only a very few pen and ink changes. I thought the guys did a great job. The LM Flight Data File worked very well. It was well organized. Some of us like to use polar star charts, some of us like mercators. I like polar, and I took the CSM backup polar star chart in the LM. That's noise level.

It was a good idea to bring the LM tape back to the command module, because we sure used a lot of tape.

WORDEN Orbit charts. There's a difference between the two of them. I don't think we looked at the Orbit Monitor Chart but once, very briefly, at the very beginning. We never looked at it again because we pretty well knew where we were. We found that the orbit charts weren't good enough for what we wanted off the charts, as far as orienting ourselves.

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SCOTT The Sun Compass. I tried it during the SEVA and it worked great. That was the only chance we had to try it. We carried it the whole way. I felt like we could use it any time. It was a very simple operation and I think a handy backup tool.

The Landing Site Monitor Chart. We used that in the simulator quite a bit to get a handle on where we were. We had it out as we went over the landing sites during the activation.

IRWIN Yes.

SCOTT It's not very good photography, but it gave us a pretty good handle on where we were over the surface.

Horizon Return Chart. That's the one on the surface that I think is a useful chart. The navigation system on the Rover worked so well that we had a tendency not to use all those charts. It would be pretty much crew-preference. To me, the most useful in training, and in driving the Rover, was the Horizon Return Chart which gave me a big picture and a horizon depiction. In retrospect, the optimum for overall location of your position would be, maybe, a 1-to-50 000 with a polar grid on it, with the reciprocal bearings, and 1-kilometer-radius circles. Then, any time you wanted to find your position on the surface, you could look at the Rover NAV system and use range and bearing to locate your position.

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IRWIN The only one I used for navigation was the 1-to-25 000, because the surface just didn't look like the enhanced photography.

SCOTT They were enhanced to the point where they gave much stronger relief than we actually saw on the surface, which somewhat degraded their usefulness.

WORDEN The Lunar Landmark Maps in the command module were very clear. It was no problem to use them. We had a series of simulated obliques leading up to the landing area. I looked at them maybe once before doing the first set of P24s. I never looked at them again, because the landing area was just so obvious when we got there.

SCOTT Sure was. Contingency Chart. We had no occasion to use it, but it looks like it's useful.

 Picking up on general flight planning, the two places in here that will require comment will be from Al on the solo phase.

WORDEN I was quite pleased with most of the general aspects of the Flight Plan during the solo phase. The checklist was integrated into the Flight Plan, and I thought that worked much better from my standpoint than it would have been if I had used checklists all the time. The only comments I have about

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WORDEN
(CONT'D)

the Flight Plan are that we really need to concentrate on making eat periods and exercise periods work-free. That's really important. I found that I was constantly being interrupted in the middle of something to throw a switch somewhere, or to do some other Flight Plan activity. I know there was a concentrated effort to delete all that preflight, but it didn't work out. Continued effort has to be put into that area to ensure that those periods are absolutely free of sequenced work in the Flight Plan. At least one period each day in the Flight Plan should be devoted to a free period so that you can take care of the housekeeping. You could take care of the other functions that have to be done on board, and you wouldn't have to sandwich them in between other periods of activity.

IRWIN I have a different view of the SIM bay than Al does. It seems like it would be better if the ground called all the actions on the SIM bay rather than having to look at the Flight Plan for them.

SCOTT Then you're tied to the ground all the time.

IRWIN That's true.

SCOTT I'd disagree with that.

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WORDEN That's right. I disagree with that. I did find that I got into a mode of operation where the ground would give me 30-second warnings on something which was in the Flight Plan. That meant that I knew the sequence of things coming in the Flight Plan, but I got a reminder from the ground. If there was a 10-minute period before the next item had to be done, then I could completely forget about the sequencing in the Flight Plan. The ground would give me a 30-second warning, and that would be a cue to me to go back to the Flight Plan and do that function. I found that very useful. In relying on the ground completely, you'd be constantly listening to the communications and waiting for the ground to say something. That would not work too well.

SCOTT We had good preflight support on all the Data File. The change proposal system had a little breakdown in comm there on a couple of items. We weren't aware of the changes going into the change proposal boards. The boss didn't know whether we supported or we didn't support. I'd recommend in the future that any changes that are being considered by the board first go past the crew so they can pass judgement as to whether they agree or disagree before it gets to the board.

WORDEN I think you need to split that into two parts, Dave. I think the procedural things should go by the crew, but there are a

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WORDEN lot of systems changes that are just mechanical and that you
(CONT'D) wouldn't want to be bothered with. You need to be aware of
 them, but I'm not sure that you need to go through all that
 paper work before the changes are made.

SCOTT A systems change involves CPCB, which is procedures. And,
 that's where we had to break down the comm.

WORDEN Yes.

SCOTT Real-time procedures changes worked okay. We had an awful lot
 of Flight Plan updates, but I guess we asked for those. We
 told them that during solo operations we didn't want any
 Flight Plan updates. When the three of us were together, we'd
 accept whatever they thought was necessary, and even though
 we were busy, I think it worked okay.

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24.0 VISUAL SIGHTINGS

SCOTT We forgot to mention, during the launch phase we went right into the sun. At one point during launch, I put my hand up to shield my eyes so I could see the ball. I was surprised. It's no problem, but it would be a nice thing to be aware of on an early morning launch like that.

IRWIN It wasn't in my window. Must have been in your window.

SCOTT Boy, the light was smack in my eyes.

WORDEN I don't remember seeing anything that we didn't expect to see.

IRWIN We thought we saw a satellite, but we decided it was probably a planet. Remember?

SCOTT Yes, that's right. We sure did.

WORDEN Yes. As a matter of fact, didn't we think that was a satellite because it always showed up at the same place?

SCOTT Yes it showed up at both sunset and sunrise. You can't do that if it's not a satellite. I mean if it's the same star, I don't think we would see it at both sunrise and sunset.

WORDEN It always appeared about the same place in the window, too.

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IRWIN Yes.

SCOTT It's written down in the Launch Checklist at the point at
which we saw it.

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25.0 PREMISSION PLANNING

SCOTT Premission planning. Mission plan. The mission plan referred to the requirements document and that was continuously updated. We stopped looking at it about 3 months before the flight because we couldn't keep up with it, and we couldn't prepare ourselves for this much activity with the constant changes that they had. I'm not sure that the Mission Requirements Document was fully completed during the flight because we just couldn't possibly keep up with it. It should be frozen much earlier than it was in our case. For instance, the scientific community came up with a definition of a comprehensive sample on the surface, which included some six or seven events, long after we had completed our training on those type activities. We just couldn't accept a change at that late date. In fact, the MRD has to be frozen at least 3 months before the flight. If there is something that needs to be added, put it on the next flight. I thought the Flight Plan came along fairly well.

WORDEN I think that for the mass of detail that went into this Flight Plan, and for the originality of the Flight Plan, I thought they did a great job.

IRWIN Yes, it was well done.

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SCOTT Spacecraft changes. We had a lot of little changes at the end, but none of them really affected the mission.

IRWIN We mentioned a couple that we weren't aware of, such as the H₂ flow.

SCOTT Yes, they changed our tape meter and then it broke, and I wonder if that was why.

Procedure changes. I think that was fairly minimized toward the end. We had quite a few early in the game, but the last month I didn't see too many.

WORDEN As a matter of fact, I thought the pen and ink changes that we saw were pretty minimal.

SCOTT Mission rules and techniques. We got an early handle on mission techniques by having the data priority meetings about 6 months before flight and got all those out of the way, and the techniques documents established as to what we were going to do. We proceeded along in that direction while the paper work caught up with us. I thought that gave us a good position for understanding the mission rules as they were developed during the simulations. We always had a fairly good handle on the techniques of the mission rules. I recommend an early start on those things. The flight directors kept us well

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SCOTT
(CONT'D)

abreast of changes in the philosophy in the mission rules,
which I thought was very good. I don't think we had any
disagreement on mission rules as we went. Everybody was in
agreement on exactly what we were to do.

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SCOTT
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which I thought was very good. I don't think we had any
disagreement on mission rules as we went. Everybody was in
agreement on exactly what we were to do.

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26.0 MISSION CONTROL

SCOTT Mission control. Go no-go's were timely. We were never behind on understanding those. Jim did you ever have any problems with flight updates?

IRWIN No, they were all very timely.

SCOTT Those late PIPA bias updates were surprising on the descent as was the 3000-foot call. We'll get that worked out.

The consumables seemed to work out well, passing back and forth the data. Our inflight gages were somewhat different from the ground, particularly in the RCS.

It was quite different. We were all abreast of the situation throughout the mission. Anything in consumables, problems anywhere? It was a good thing somebody found the 25-pound water delta, that day we had the leak in the LM. That was a sharp bite because we could have ended up with an unexplained 25-pound water loss, and a bunch of water in the back of the LM that might have frozen up and broken a line or a wire or something.

RCS fuel. I didn't look at the command module's when we got back down, but I'm sure we had plenty. We had both rings and it was a nominal entry. Service module: we ended up with 35 percent.

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SCOTT In the orbital operations, you never got close to the red
(CONT'D) line, did you?

IRWIN The last number I recall hearing was 15 percent above the red
line on one quad. There was some concern about the second
day of lunar orbit operation that we were expending fuel more
rapidly than we should have been. We were going to have a
problem with the red line. They called up a weight change
for the CSM to try and take the DAP into firing fewer times,
to conserve some of that fuel. That didn't work. So we went
back to the actual weight and nothing else was said. We never
compromised any of the operation and we ended up not even
close to the red line. I never did hear a number after the
15 percent, but I assume that we were comfortably above it.

SCOTT The LM RCS was great. We ended up with something like 80 per-
cent when we came in there, in the final breaking. DPS fuel.
We had plenty. We had a minute and 51 seconds of hover time
remaining. SPS fuel. I think that was all planned and uti-
lized, with a couple percent left. Real-time changes from
mission control. No comments. Communications. The system
worked well all the time.

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27.0 HUMAN FACTORS

27.1 PREFLIGHT

SCOTT The health stabilization and control program is a good idea. There was some concern about us catching a bug just before launch and one of the reasons we didn't catch it probably was because of the isolation.

IRWIN Yes, I thought it was a good idea. It gave us a chance to rest up a little bit, too.

WORDEN I felt quite rested before we went.

SCOTT I did too. I think we all got a lot of rest; everybody was in good physical shape, healthy, and ready to go.

Medical care. We had no problems in that area. Time for exercise, rest, and sleep was adequate. There was no pressure at all during the last 3 weeks. As a matter of fact, we were trying to find things to do.

Medical briefing and exams. My impression is that the medical protocol seems to grow and grow, and everybody wants a little bit more. It's an awful lot. Because of the requirements of the mission and the greater demands on the crew during a mission, it would be nice if we could keep the same level of

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SCOTT (CONT'D) medical, activity instead of increasing it. In each test, each group of people seems to have one or two more little things they want, and it just adds up to one big, big step. I think we're reaching the limit.

IRWIN I'm glad we went on that low residue diet before flight.

SCOTT You think it helped.

IRWIN I might have had to go the first day, if I hadn't been on that diet.

SCOTT Eating habits and amount of food consumed at F minus 5 to F minus 0. We went on the low residue, and I guess it helped.

27.2 FLIGHT

SCOTT Appetite and food preference. Before we went we decided we were going to try to eat everything on board as prescribed on the meals. That's exactly what we did. We ate everything there was to eat except the bacon squares and a few other things. The more you eat, the more your system works and the more waste you have. That created a time problem in that everybody had to use the waste management procedures at least every other day. That's time you have to allow for. It's still a good idea to eat because I think we all felt very good throughout

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SCOTT (CONT'D) the flight. Once we got on the curve of eating all the meals, it was no problem. In fact, I think we all got pretty hungry when it came to be meal time.

IRWIN In that connection, I just wish the packages in the pantry had been labeled per meal without having to search for items. We wasted a little time there.

SCOTT In other words, have meals all the way through, and have a pantry with extras. I think that's a good idea. Changes in food preferences as the flight progressed, were not noticeable, except we all wanted scrambled eggs for breakfast.

WORDEN That's right, and we all got off the bacon squares.

IRWIN I sure could have gone for some more of that chalais soup.

SCOTT That's the kind of thing that's an individual preference, and I don't think it's too meaningful for us to go through our preferences on the foods. In general, the food was very good and there was enough variety that we were all happy and everybody ate good.

WORDEN The wetpacks were great for giving you something to chew, giving you the bulky kind of food that you wanted, something that's already prepared. However, the flavor in the wetpacks left something to be desired. It discouraged me, upon first

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WORDEN
(CONT'D) opening up a wetpack, to first see an amount of gray grease that the food had been cooked in. That didn't make it very tasteful.

SCOTT Catsup and mustard helped. Chili sauce, next time, might even be better. No deviations. We stuck to the eat periods and and the programed menus. Food preparation.

IRWIN Well, you noticed gas.

SCOTT Yes, I thought there was too much gas. The cans worked okay and once we learned how to use the soup packs, they worked okay.

WORDEN Yes, there's a certain amount of readjustment you have to undergo to get use to opening those things. A comment on the canned food. Those things that are packaged in metal cans, in a liquid, caused us some problems, and I don't think we ever really solved the secret of opening the cans without getting some of the liquid out.

IRWIN Some of them had almost too much liquid in them, such as the peaches.

WORDEN They were very difficult to open without spilling some of it; without getting some drops of liquid.

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SCOTT We used the germicidal tablets until we ran out of them. Some of the packages we brought back were without the tablets because we just ran out. Odors were okay. We ate everything on the surface. I thought the water tasted good, except for the gas we mentioned.

WORDEN I was expecting more of a chlorine taste in the water than I actually found. That was quite a pleasant surprise.

IRWIN I frankly couldn't tell the difference in LM and command module water.

SCOTT We talked about the sleep. We recorded all that. Restraints were okay. Everybody sleeps a little different. Everybody will find out the way they want to sleep. Exercise. We discussed that. Everybody exercised when they were supposed to, and we talked about the ergometer. Anybody get any muscle soreness?

WORDEN The first couple of nights, I had a very sore back. In talking to the doctors, after the flight, it was readily explainable in terms of the one-g conditioning that your back muscles have. It's a normal thing. It's just something to be aware of.

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SCOTT Inflight oral hygiene. We only had one tube of toothpaste and Al happened to get it. We always had to borrow Al's toothpaste, and we didn't have any on the lunar surface.

IRWIN You took your tooth brush to the lunar surface. I didn't. I just gave up brushing my teeth after reaching the lunar surface and from then on I just forgot it.

SCOTT Sunglasses were okay. Unusual or unexpected visual phenomena. I don't remember any problems there. Distance judgment versus aerial perspective during EVA. Everybody knows it's hard to judge distances on the surface. Everything looks much closer than it really is.

WORDEN We've already commented on the Lexan shield. During those periods when we were exposed to the ultraviolet, I never noticed any discomfort; never noticed any effects on my eyes at all, during the times when the Lexan shield was up.

SCOTT Medical kits. We didn't use them, except for the biosensors and these were discussed.

IRWIN I'd like to suggest that they put the right size cups in there.

SCOTT Housekeeping. We discussed that. Shaving. We didn't. Dust. We discussed that, relative to the vacuum cleaner and the cabin fans. Radiation dosimetry. The PRDs were a constant

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SCOTT
(CONT'D) problem because they just kept having to be searched for. We were being asked about PRDs at odd times. We got out of sync the first day and never got back in. I didn't realize they were quite that important, especially the low numbers we were getting. The crew ought to pay attention to having those things around because the doctors will ask you. We never touched the radiation survey meter. Personal hygiene. I rarely used those wipes.

WORDEN I found the wipes a little bit disagreeable, in a way. I didn't like the odor of the wipes.

IRWIN We commented that they ought to be scented.

WORDEN The one bar of soap that we had, that Jim took, was a very good idea and I would suggest that in the future. You get almost as much a refreshing feeling from the scent of that soap as you do from using it. I think that is a good idea and I think we ought to consider scenting the wet wipes.

SCOTT I thought the towels worked great. If you had a bar of soap and towels, you'd be in good shape.

WORDEN I don't think we used but about 10 percent of those wet wipes.

IRWIN I threw most of mine away.

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WORDEN There was a large package in the food locker when we finished.

IRWIN You guys used the combs. Somewhere, I lost mine.

SCOTT Your light-weight headset never worked.

WORDEN That's right. The microphone in my light-weight headset never
did work.

SCOTT Jim left it on the surface somewhere.

IRWIN The last time we saw it was when we were on the surface.

WORDEN A spare light-weight headset should be considered.

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