264 pp.

CONFIDENTIAL

MSC-07631

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 17 TECHNICAL CREW DEBRIEFING (U)

JANUARY 4, 1973

PREPARED BY
TRAINING OFFICE
CREW TRAINING AND SIMULATION DIVISION

This document will automatically become declassified 90 days from the published date-.

NOTICE: This document may be exempt from public disclosure under the Freedom of Information Act (5 U.S.C. 552). Requests for its release to persons outside the U.S. Government should be handled under the provisions of NASA Policy Directive 1382.2.

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

INDEXING DATA

DATE	OPR	#	T	PGM	SUBJECT	SIGNATOR	LOC
01 JAN 73	MSC	MSC-07631	R	[illegible]	[illegible]	[illegible]	[illegible]

CONFIDENTIAL

CONTENTS

1.0 SUITING AND INGRESS

CERNAN Except for one small item, the entire suiting and ingress and all equipment supporting it was nominal. There were no complications or problems. Suit circuit checks and cabin closeout were rapid and complete and, to the best of our knowledge from inside the cabin, went very well.

EVANS The anomaly Gene mentioned was my insuit drink bag. Unfortunately, I didn't try it out prior to putting on the helmet. I wish I would have now, because the waterbag itself had gotten twisted sideways underneath the neckring instead of hanging straight down from the neckring. The tube was crimped and I was unable to get any water whatsoever out of it.

2.0 STATUS CHECKS AND COUNTDOWN

CERNAN Ground communications with the spacecraft and all the launch preps for a nominal on-time launch went well. There were no spacecraft anomalies or problems during the launch prep. All systems checked out well. Controls and displays went well through T minus 30 seconds, when there was an automatic sequencer hold due to a potential problem that the ground support equipment saw on S-IVB pressurization. However, to the best of *my* knowledge, the S-IVB was GO on the cockpit displays. The S-IVB pressures were nominal, but, nevertheless, we had an automatic hold in the sequencer at T minus 30 seconds. From then on, for 2 hours and 40 minutes, we had a series of 20-minute recycles. I don't know exactly how many now. Did we ever get down to 8 minutes one time in the count?

EVANS No. Once we got started below 20 minutes, we went all the way.

CERNAN The problem turned out to be apparently in the software of the ground support equipment. The workaround was caught up, checked out through the Cape and Marshall, and once the count picked up, we had two azimuth updates.

EVANS We had two azimuth updates, because the first recycle was more than 20 minutes, wasn't it? It was more than 20 minutes and we recycled to that point and then they found out that they

EVANS (CONT'D) weren't going to be able to pick it up again in 20 minutes. And we stopped at 20 minutes and made the second azimuths.

CERNAN The point here being, both azimuth updates in the spacecraft went well. The *CMP* put them in the computer. The computer took it. I watched the IMU torque, After each one of those, they had to reset the GDC, which worked fine. So we launched with a good GDC following the platform. The only difference was a small roll angle, and it was reversed, because we had gone through 90° on the azimuth change. But that didn't really bother anything because the roll came in on time in a reverse direction. It was a small roll that culminated in just a few seconds.

The count and lift-off, through the yaw and the roll program, were nominal once we got through T-0.

Distinction of sounds in launch vehicle sequence countdown to lift-off - I think the only thing that really comes across in there is that at some point you get a good vibration. At some point in the countdown, you get a good vibration as you're sitting up there. It's not part of the CSM's operation, so you're not sure what's going on. And this happened in the CDDT and, of course, all we did was check and find out we were doing something with the booster.

EVANS When they ran through some gimbaling programs.

CERNAN The major portion of the launch count has to do with checking out the systems, so the commander stays very busy and many times on separate loops. The entire EDS system checked out very well. We only checked it out once in the initial count and during most of the recycle we stayed in EDS AUTO and then we de-armed EDS AUTO but still maintained a manual EDS capability to abort during that recycle time. We picked EDS AUTO as part of the T minus 20 recycle for final lift-off.

3.0 POWERED FLIGHT

CERNAN The S-IC ignition - The lights started going out at 7 seconds, and somewhere around 3 seconds they were completely out. You could feel the ignition. You could feel the engines come up to speed. Just prior to lift-off and during the first few seconds of lift-off when we were near the pad, both the CMP and I could see the reflection of the engine ignition out the left-hand window and the hatch window in the BPC. We could not see the fire but could see a red glow through the windows reflecting apparently off the surface. Ignition was like a big old freight train sort of starting to rumble and shake and rattle and as she lifted off. We got a good tower clear. As you go through max-q, as in the past, it gets very rough and much noisier, but I don't think we ever had any trouble hearing each other in the spacecraft. I had my intercom very high and all my S-bands and tweaked everything up prior to lift-off. We went through max-q and the only unusual thing going through max-q, considering wind components that we had was that I saw 25 percent on the ALPHA going through max-q. The yaw needle was right on, but the pitch needle had dropped to a degree and a half at the most. I guess I didn't really expect it because of the predicted wind components. After we got through max-q, you could still certainly tell the bird was burning as we pressed on toward staging, but it got much quieter and it was

CERNAN (CONT'D) very evident that you were through max-q when that time came. We had center engine shutdown on time. We had staging on time.

I don't think it's ever been recorded on a daylight launch before, but as soon as the S-IC shut down during the time involved in recycling and getting the staging sequence going and the S-II lit off, apparently the trailing flame of the S-IC overtook the spacecraft when we immediately went into that zero-g condition. And, for just a second, as the S-II lit off, we went through the flame. It was very obvious. We could see it out of both windows. I particularly could see it out of the left-hand rendezvous window of the BPC. It was not a smoke; it was not an orange fireball; it was just a bright yellow fire of the trailing flame of the S-IC; and it happened for just a split second. Then we got off on the S-II and things got very quiet and very smooth and was a very long, quiet, smooth ride.

EVANS I really wasn't watching the lights because I guess I didn't expect the thing to shake quite as much as it did. To me, I felt like I was really vibrating. I wanted to find out what was making me vibrate. I wasn't expecting that much vibration when the S-IC lit off. At lift-off, again, once it got vibrating, I didn't feel the yaw. I was watching the needle on the thing but didn't feel the yaw, though. The shaking increased a

EVANS (CONT'D) little bit up to max-q and then there was a different type of shaking. It was more of a vibration, I think, going through max-q. And there was more noise associated with going through max-q. Of course, with the shutdown of the S-IC, I think that was about 4-1/2g.

CERNAN We pushed 4g.

SCHMITT Just pushing 4g on the thing and it quits just like that. I was prepared for it because Gene had said, "Hey, brace yourselves because it is going to happen," and it happened all right. It just flat quit when we went from 4g to 0.

CERIVAN The great train wreck.

SCHMITT I think in all those booster cutoffs, it's hard to see how rapidly the g-level decreases. I guess the only other comment I have is that I think that it is good to do a lot of simulation about malfunctions during launch, but up through max-q it is a little bit unrealistic to think that you are going to analyze a malfunction in the spacecraft.

CERNAN To sum up the S-IC, I personally didn't think it was any different than *my* previous ride on the S-IC and up through this point being a night launch really didn't make any difference at all. The only thing I did different that I hadn't really though a lot about until I sat on the pad and began to think

CERNAN (CONT'D) about staging was, just prior to staging, I took my hand off the abort handle and held the support arm rather than the translation control handle until after staging. I did this just a couple of seconds prior to staging. I had talked about it with John Young a little bit prior to the flight and it turns out that's what he did, also. Probably a good thing.

The S-I1 ignition was very smooth. We got skirt sep right on time. I could feel skirt sep going. We had tower jett, which was really sort of spectacular at night. I think the LMP is going to add something to it, but from the left-hand rendezvous window, I could not only see the flame, but the inside of the BPC seemed to be lit up. Of course, it doesn't stay there very long; it's gone in just a split second. But it was a very spectacular sight at night to see that tower go against the blackness of space out there. We could see guidance come in very definitely. It was not as big a pulsation as I've seen on the simulator but I did see the needle and the spacecraft did change its attitude slightly.

You could see the mixture ratio shift. It was just a long, smooth, quiet ride. Inboard cutoff was right on time. You could feel it, a definite physiological feeling. Of course, the g-meter saw it also. The S-II cutoff, as Jack said, is again very sharp, almost instantaneous, from almost 4g to 0.

CERNAN (CONT'D) But on the S-I1, although it's sharp and a very hard hit, you don't unload the entire stack like you do when you're on the S-IC. The staging was very smooth. It did not seem like an exceptionally long time before we separated and the S-IVB lit off.

SCHMITT On the tower jett, I wouldn't say a split second. As a matter of fact, I was surprised it lasted as long as it did. It was a few seconds.

EVANS I couldn't see the rocket go. All I could see was an orange glow out the center window.

CERNAN While we were on the S-II, we would see no indication of light from the engines. We were just thrusting out in the darkness of space. I tried to see stars for potential mode IV and, of course, at that time, mode II abort and turned the lights down on the left side once or twice. But even with the lights down (we had the LEB lights relatively low), in my estimation, it would have required all the lights in the spacecraft to have been off and certainly more than a few seconds to become night adapted to be able to see through the windows and pick up stars that would have been able to help in an abort situation had you lost the computer and the SCS. We had looked, potentially planned to use those stars in an abort condition if we had to. We had excellent constellations to look at. They obviously

CERNAN (CONT'D) were there, but I could not see through the low glow reflection on the window even with our lights, floodlights, turned almost all the way down. I even went to the extent of trying to shield my eyes on the S-II and looked out the window and I still could not pick up anything that I could have recognized for an abort. I also could not pick up any night horizons during that point in time which I thought I might be able to base on seeing where the stars cut off and where they do not.

SCHMITT We had another indication of that during entry when we were looking for a night horizon and finally saw it, but it was extremely hard to find.

CERNAN We got lit off on the S-IVB, and, unlike the flame we flew through on the S-II, we did not do that on the S-IVB. I don't know where the reflection came from, but I could see the reflection from somewhere out the forward window. Either it was the S-II trailing flame trying to overtake the vehicle but didn't quite make it, or it was S-IVB ignition reflecting off the S-II because there's no atmosphere up there at that point. But I did not see a flame, but a residual back light out that window just for a short period of time, either right at staging or just at S-IVB ignition. As I think back, my best guess would be that the same thing happened on the S-II, that the trailing flame, when you go from 4g to 0 instantaneously, tends

CERNAN (CONT'D) to overtake the vehicle. But in the case of the S-II, it's not nearly as big a pattern and just didn't quite make it up the stack. I just saw some of the glow of it. That's my best guess. After the S-IVB ignited, we never saw anything except the APS firing throughout that burn.

You could see the mixture ratio shift.

SCHMITT But PU shift, both vehicles, was surprisingly noticeable.

CERNAN Communications throughout the booster phase were excellent. I never had any problem hearing either Stony or CAPCOM.

Controls and displays performed super.

Crew comfort through powered flight - I felt very comfortable throughout the entire flight in orbit.

As far as I'm concerned, there was no pogo on the burn.

EVANS No, none.

CERNAN Summing up the birds. If you want to put them in more layman terms, I think the S-IC acted and performed like some big, old, rugged, shaky, big monster. It has to be noisy, has lots of vibration, and smoothed out somewhat after max-q, but still was a rumbling bird. The S-II was a Cadillac: quiet, less than lg flight most of the time until we built up our g-load prior

CERNAN (CONT'D) to staging. It was quiet, smooth, had very little noise, or feeling of rumbling or anything else. The S-IVB: a light little chugger is probably the best way I can describe it, which is not different than I remember it in the past. It just sort of rumbled on, not anywhere near the extent of the S-IC, but just sort of continued to rumble on through the burn. After a while, especially during TLI, it got to be a very pleasant, warm feeling that she was burning like she should burn.

EVANS Chugging, I think, has two different connotations. I felt the S-IVB was more of a very light rumble in the background, something that is kind of rumbling as opposed to chugging. A chug to me is a bang-bang type thing, and to me it was more of a rumble.

SCHMITT I agree, it may be a sense of rumbling but the ride was smooth. I could sense some activity behind it, but I wouldn't have said that it was chugging.

CERNAN I'll modify chugging to say it was a hummocky chug, just a rolling type. Nothing different, and, as I say, the best recollection, similar to the S-IVB I had the opportunity to ride on before, but probably even more steady and continuous flow of light rumbling.

4.0 EARTH ORBIT AND SYSTEMS CHECKOUT

CERNAN Evaluation of insertion parameters - We got a good onboard orbit. Ground gave us a GO for orbit.

The postinsertion systems configuration systems checkout and the complete spacecraft and booster preparation for TLI went extremely smooth and extremely rapid. By the time we came back over the States on the first pass, we were ready and the spacecraft was ready, and we were configured and could have gone on a TLI-0 without any hurrying and scurrying whatsoever. From that point on, when we got our GO on the booster and a GO for TLI-1, it was an Earth-orbit, an extra Earth-orbit ride to sit back and just monitor our systems in the spacecraft and see what we could see from Earth orbit in terms of viewing. It was an extra 90 minutes of the flight that, if you really had to do without, you could have. And it was not hurried. It was very comfortable, even progressing toward the TLI-0.

SCHMITT Let me add just a couple of things. One thing that we had because of the later launch was a number of LOS/AOS updates to plot which did not interfere with our getting through the checklist. The checklist, I had a feeling went more slowly than it ever had. But, as Gene says, still with plenty of time to meet the zero up time and to have essentially a whole

SCHMITT (CONT'D) daylight pass to just relax and look at the Earth. We had one note here. I didn't even remember until I read it here that in the ECS checks the hydrogen pressure indicators, or part of the indicators, were reading about 10 percent lower than we expected. But, as I recall, it may have been expected.

EVANS The optics cover jettison worked as advertised. We jettisoned the optics cover in the daylight and you could see the two covers flipping off straight down the optics path.

CERNAN I think everyone reacted normally to weightlessness. There was no feeling of disorientation or vertigo or any other disturbances at that point. The CMP is the only one who left the couch prior to TLI and that was for his P52.

EVANS I didn't get that fullness in the head at that point at all. That wasn't until we'd been up there for 5 or 6 hours.

CERNAN Launching at night, we just had a somewhat different view of the Earth than most other flights have had. The first real view we got of being in orbit at that point was pretty spectacular because it happened to be Earth sunrise and that's a very intriguing and interesting way to get your first indoctrination to Earth orbit.

SCHMITT The transcript contains some descriptions, by all three of us, of sequences of that sunrise which, in the color banding, may be of some significance for other people.

5.0 TLI THROUGH S-IVB CLOSEOUT

CERNAN The TLI burn from the ground targeting point of view and targeting went just as written. We went down the checklist and cue card without any problems or any anomalies, without any changes except to the manual. We had a change to all our manual angles to monitor the S-IVB burn because of the late lift-off. We wrote those down on our cue cards and were going to use those in case we had to take over during the burn. We had to change to the nominal and we rewrote both of those on our cue cards. That's the only basic change I think we had.

SCHMITT The communications all through Earth orbit were excellent, as I recall. There was no difficulty getting the pads up. They came up expeditiously and well read. We actually gained a little time because we didn't have television. But we didn't need it. We could have configured it for use.

If there's ever any attempt to do weather observing from Earth orbit, in the low orbit like that, you're going to have to have a very clear plan of where you're looking at what time you're looking in order to make reference as to where you are because you're moving so fast. You can't really keep track of where you are and specifically in terms of weather observation. Later on, once you get the whole globe in view, it's

SCHMITT (CONT'D) a relatively simple thing to pin down to within a few degrees of latitude and longitude where you are looking on the Earth.

CERNAN On all these lunar missions, we've never really done much in Earth orbit except get prepared for the TLI burn. Future Earth-orbit flights need this continual map update, you're right. You have to do that. As I think back to 3 days in Earth orbit, unless you continually follow a map and a map update as to your rev as you progress around the world, what part of that world you're looking at is very difficult to follow except the precise piece of real estate you're flying over.

SCHMITT The lunar orbital operation is somewhat different because you stay in the same groundtrack much longer I think.

CERNAN The S-IVB performance was outstanding. She lit off on time and burned for 5 minutes and some odd seconds as I recall. And we had shutdown on time. The residuals and the EMS on the spacecraft are written down somewhere, but they were all very nominal, very excellent. We stayed in IU. As the S-IVB maneuvered, we flew through a sunrise during TLI, which in itself was also very interesting, very spectacular. We had nominal S-IVB performance after shutdown; and maneuvering

CERNAN (CONT'D) to the sep attitude, we went through checkout load NOUN 17 and NOUN 22. There was again no noticeable pogo. The S-IVB sounded and performed just like it did on the insertion phase burn and I'll let the *CMP* pick up the separation and the transposition and docking.

SCHMITT We all were very aware of PU shift.

CERNAN I guess I could have called that or I was looking forward to seeing it. It is on my checklist. It's on my cue card and I've looked for it and I've seen it in the simulator.

SCHMITT It just didn't register in the simulators, I guess. And the other thing flying through that sunrise, it did to a small degree interfere with visibility in the cockpit.

CERNAN It didn't bother me from the standpoint of monitoring on my side at all.

EVANS As far as the separation from the SLA, it was nominal. There's a louder bang than I expected from pyros. This is the first time that I really noticed that in the plus-X translations, or in any translations as far as that goes, you get about ±0.4 per second rates within the dead band. As opposed to the simulator, it has about 0.1° per second on any of the translations maintaining attitude.

EVANS (CONT'D) Formation flight was great. The S-IVB by itself was as steady as a rock out there. No problems. I couldn't tell it was dead banding or moving at all. I came in relatively slow, about 0.1 ft/sec, somewhere in that area.

Docking was nominal. As soon as he got capture on the thing, there were no rates. Everything was steady. I didn't have to handle the translation controls or null rates at all. We went directly to hard dock. There's more spacecraft movement during that period because I feel that the COAS and the docking target were off a little bit. And I don't say misalined, but it's a little bit off. But, of course, it was in limits and was no problem.

CERNAN When we went to retract, we got our big ripple fire - bang on the latches, so we had a relatively good hard dock. We only got one gray indication on the talkbacks. The other one was barber pole.

SCHMITT There's a lot of descriptive material, I think, in the transcript on that. As I recall, we got two pulses in the ripple fire. It seemed like there was one or two latches and then the ripple fire.

CERNAN I just recall a woomph!

SCHMITT I think, if you look at the transcript, we said that there were two pulses to it.

CERNAN Subsequent inspection of the latches showed that there were three latches which were not made entirely. One of them, as I recall, had to be recocked. Anyway, it turned out that once we got those three latches (which at that time looked like they were operating properly) reset, we got two barber poles on the talkbacks. Ultimately, latch 4 was found to be unseated on the ring, although, at that time, it looked nominal. The attitudes given us were excellent; we were able to watch the S-IVB maneuver. We were able to see the S-IVB vent and it all went well and nominal.

SCHMITT It was very clean as far as any debris or anything coming out during the docking phase, and I could see a few little things that were bouncing around inside around the LM, particles of some kind. It was nothing like previous flights where they had a lot of debris. It was very clean.

CERNAN As I recall, we undocked and separated just a little earlier than had tentatively been planned, but that was no problem because we were ready to do it.

6.0 TRANSLUNAR COAST

EVANS The IMU realignment and optics calibration - We've mentioned the visibility of the stars in talking about the systems in the section on systems. Systems anomalies - We already hit that one. Heat flow demonstration - it worked great. There were no real problems on it. It was a real time operation with ground. Everything is recorded on the down-link.

SCHMITT There was some problem with the orientation of the experiment. As I recall, you reoriented it between the two experiments. I never quite understood why there was that problem. It was a checklist problem or something.

EVANS The problem was something about the orientation of the radial experiment with respect to the X-axis. I pointed the radial experiment along the X-axis. It was supposed to be perpendicular to the X-axis, but it shouldn't have made any difference in the results anyhow.

PTC - We got it started and had no problem.

Cislunar navigation or navigational sightings - It's already mentioned in the systems part.

SCHMITT You mentioned apparently you had a very good Delta-H determination - horizon determination.

EVANS The P23s worked out great. The vehicle is heavy enough that you can control it quite easily with minimum impulse. I used the EMP on P23 so that once you had the star in the field of view and all lined up you could recycle through the program without getting all the maneuver data on the thing. While it was recycling, I could just watch the spacecraft and not let it drift too far out of field of view. When it came back in, I would maintain the star in the middle of the crosshairs of the sextant and maneuver the spacecraft so I could get the substellar point and maintain the substellar point. As it turns out, I guess the resulting Delta-H is within the limits that are recorded in the E-memory.

Midcourse correction - I think that's all recorded on the down-link. There should be nothing anomalous about that.

Photography - Jack, I guess you've taken most of the pictures on the translunar coast.

SCHMITT Most of the photography came to GET within a few minutes. It was almost a continuous effort at the beginning of the day and maybe in the middle and at the end with some irregularities - getting a continuous record of a very nice view of the Earth and the weather patterns. We had about three-quarters to two-thirds Earth through most of the translunar coast period. And that should be in the photographic logs on the ground.

SCHMITT (CONT'D) High gain antenna performance - Through the whole mission, not just translunar coast when I was using it, it was perfectly nominal. The ground did most of the calling on it. Between omis and high gain when they didn't call, it was easy enough to get the high gain to peak up. Usually in MANUAL and WIDE and either AUTO or REACQ depending on the occasion, it seemed to work very well. I wasn't aware of any high gain anomalies.

EVANS Daylight IMU realine and star check - Again you can't see the stars through the telescope. Most of the time you can't see the stars through the telescope. However, if you have a good alinement and it shows up in the sextant, there's no problem.

ALFMED experiment - I think that's all recorded on the down-link. The one thing that I might add to that is that prior to this time I hadn't seen a light flash. So I put it on any-how and sure enough the light flashes are there. And that's all recorded.

SCHMITT In the experiments notebook, where the LMP was taking notes on the ALFMED experiment comments, it was necessary in this trans-lunar coast period because we were on omnis and PTC. It is very difficult with two guys observing to take notes if they both start seeing marks at the same time. Interestingly enough maybe even for the experiment the marks seem to come in batches.

SCHMITT (CONT'D) They'd be periods of quiescence, then both of us would start seeing marks. So the notes are relatively incomplete and, hopefully, the DSE plus the down-link will fill in all the gaps. It's feasible to take notes but they will be incomplete compared to the verbal description.

EVANS CM/LM Delta-P - Nominal.

Orbital science photos - We really didn't have any on trans-lunar coast.

SCHMITT Nothing was called out. We used about a half a mag on the Earth, maybe more.

EVANS More than that. We used a full mag before we got to the Moon.

LM and tunnel pressure was okay, no problems.

Removal of the probe and drogue - Went as advertised. Worked great.

Odors - Every time I got up in the tunnel after docking or anytime, there was always a musty burned odor or something. It's hard to describe.

SCHMITT Like a powder burn.

EVANS Kind of like a powder burn, I guess. This was there both in lunar orbit docking and transearth docking. This was the second day we were out when we finally went up in the tunnel. Every time I opened up the tunnel, that's what it smelled like.

We didn't mention the SIM door jett. I guess I never did see the door. You guys wouldn't let me up to the window.

SCHMITT Yes, we saw the door. I didn't get it right away. I was supposed to be taking pictures out of the window.

CERNAN I saw it right away out of the hatch window. You should have been taking pictures out of the hatch because it wasn't immediately obvious out the window. It came off just as clean as a whistle, with almost no tumbling until it got 20 or 30 feet away from the spacecraft. Then you could see that there was just a little roll and a little pitch as it drifted on away, but very very little. Not a great deal of debris and garbage as I recall came off with it either. You could probably sum up all the pyro operations by saying there are absolutely no questions. They're just good, solid, hard thuds, including SIM door jett. Just a big solid bang, really not that much different than some of the other big bangs when you separate the spacecraft. They're just all big, hard, solid clunks.

SCHMITT I don't remember what Apollo 16 said about it. Apollo 15 was suited, and they commented they didn't even know it went.

CERNAN I'm surprised at that, even suited. It was a very definite jolt to the spacecraft when the door was jettisoned.

7.0 LOI, DOI, LUNAR MODULE CHECKOUT

CERNAN The only thing leading up to LOI that had to be changed in the Flight Plan or in the Cue Cards, since we did a 2-hour and 40-minute clock update which by the way went perfectly, was the fact that I had to replot all the LOI abort parameters on the card. But the words came up very smoothly, and we just replotted the curve and changed the numbers. We had all our LOI abort constants and numbers for the new LOI configuration.

SPS burn - I thought the SPS burn was very smooth. We had an on time burn. The burn report came back to you, and the residuals and everything were just as nominal as could be. It was just a short little "g-thud," if you want to call it that, at ignition; throughout the burn, it went smoothly. Jack, you got anything about either one of the LOI or DOI SPS burns?

SCHMITT They were all auto shutdown. We covered the problems before.

Gravitational Effects on the Spacecraft Attitude - That was on rev 1, wasn't it, where we had the pan camera going and we had it all figured that we had one jet firing and the gravitational effects were supposed to keep the spacecraft within that dead band. Sure enough, it did. At least, we didn't get out of the dead band at all and didn't have to change the DAP at all on

SCHMITT (CONT'D) the first rev. This is to keep the jets from firing into the mapping camera.

EVANS Communications - We never had any problems with communications at all throughout the flight.

CERNAN PGA Donning - Our PGA donning practice was a worthwhile exercise. It takes a lot of work to get the suits unstowed and stowed, because putting the suit on in zero-g is just a little bit different. Unlike the previous flight or two, none of the three crewmen had any problem in donning or doffing their suits. I'd say donning is easier in zero-g than doffing. The CDR and the LMP helped each other with the zipping on every donning and doffing, as we've done in training. We had no problems at all. I'm glad that we were aware of the problems that Apollo 16 had. I think we were more conscious of the potential problem that existed when zipping the restraint zipper. We were conscious of it and had sort of trained in a direction to cover all bets on being able to zip up. I would say that in zero-g the zipper was a little bit more difficult to zip, but certainly I can't really say it was a problem for either one of us.

SCHMITT The only problem was that little blue donning aid always got in the way.

CERNAN Every time we zipped it, we hooked the zipper coming around.

SCHMITT One time, I can't remember whether it was on the surface or in orbit, I got some s'ing in the lower portion of your outer zipper, and we lost maybe 5 minutes while I worked that over. Other times, I learned that you just have to move through that smoothly, and it's no problem.

CERNAN Tunnel mechanics and pretransfer operations - They all went as advertised.

SCHMITT We might mention that we did take that extra film magazine over there. That was purely because that was preplanned in our minds, an extra 16-millimeter magazine, mag EE, because we felt that we just didn't have enough film to get the orbital CSM/LM activities in addition to the planned activities for descent/ascent and lunar surface.

CERNAN If you're going to use that film during that period of time, it's better to have it in the LM than in the command module, and if it weren't used, you could always bring it back and use it in the command module. That worked out fine. I think we used it all.

SCHMITT We used it but there was something wrong with the mag though.

CERNAN We had a gear strip in the mag, apparently.

SCHMITT It showed a half a magazine of film usage, so we did something with it.

CERNAN The condition of the CSM thermal coating was excellent.

SCHMITT Comm checks - We did have an S-band comm problem initially. I talked to some guys a little bit last night about it. As near as I can tell, it was primarily the combination of two things: (1) Up-link data dropouts which were causing the problem on the lockup, plus (2) some phasing, when I would switch antennas when they would just about have lockup. I think we're going to have to wait until we get with the communications people in the systems debriefings to really work that out exactly what was happening. It was a combination mainly of ground problems of getting lockup plus the unfortunate switching on my part.

The transfer and restowage of equipment were nominal. I can't think of anything right now that was a problem.

8.0 ACTIVATION THROUGH SEPARATION

CERNAN That's probably one of the most nominal parts of the mission. It really went smooth. We oscillated on the timeline. We'd get a little ahead, and then we'd get a little behind; we'd pick up a few minutes, then we'd loose a few minutes. Basically we worked around the nominal timeline. I certainly wouldn't want to shorten it any, but we came to the milestones on time and met the ground at the right places.

EVANS Prior to LOI, we manually pressurized the SPS, which was no problem. It was because of the oxidizer helium.

In all the sims we never got suited in the spacecraft. We never have all three guys in there trying to get suited and going through the sims. So the sims for the CMP were fat, dumb, and happy. There is all kinds of time in the sim; you could go out and get a cup of coffee and come back and still pick up everything. It's not that way in the real world. You get into the real world out there and you work your tail off trying to keep up and get things going and get suited. When I'm scheduled to do the P52, the CDR and the LMP are down in the LEB getting suited. There was no way I could do the P52 at that time. By the time I had a chance to do the P52 at the sep attitude, the optics were looking down at the Moon, so

EVANS (CONT'D) I'd have to manually roll and do some pitching to get the optics back up in the air, in the daylight, until I could get picapar to work. And when I finally got the P52 on, I had a little bit of a problem getting *my* suit on that day. There was evidently an "S" or something right in the back part of the crotch. I had a heck of a time getting the zipper across that little S-band thing by myself, which was back there where I couldn't pull it through with the lanyard. I finally backed it off the other way to make sure everything was all clean and cleared out. A little squishing sideways and a contortion here and there, and I finally got the zipper all the way around. I think the rest of it was nominal. I was down in the LEB when you guys lowered your gear, but I could still feel the clunk in the CSM.

CERNAN You could feel it in the CSM?

EVAN'S Yes.

CERNAN We could feel it in the LM, and we could also see the forward gear and the ladder.

EVAN'S Once I went back up to the couch, I could see the gear sticking out, too.

CERNAN Which one?

EVANS Whichever one is over there.

CERNAN Did it have the ladder on? Probably not. I think the ladder is on one of the Y-struts.

EVANS I think so.

CERNAN Well, anyway, that's interesting. I didn't know you could feel it over there.

EVANS Yes, I could feel it when you dropped.

CERNAN In the rendezvous radar or the landing radar self tests (the transcript will have it) there were some residual numbers in the registers that I had not seen before during these tests, when I brought up VERB 63. They didn't affect the test. The tests came out very well, and there's only one other slight anomaly in the rendezvous radar and that was during the rendezvous radar test. It was either on this rendezvous radar test or the rendezvous radar test prior to lift-off - I think it was shaft. I did not get the cyclic oscillation in the DSKY on shaft. But the interface was good, and I'm not sure what the particulars of that problem were. At undocking we had P47 running in the LM, and I got zero in all three registers, zero residual velocity as a result of the CSM soft and open

CERNAN (CONT'D) total undocking. Systems operation throughout that time was normal. Vehicle performance was as expected, in terms of attitude control.

Lunar landmark recognition - We were able to be in attitude and recognize and look at the landing site on that first pass when we went over. The MSFN relay worked. Generally throughout the flight, I think MSFN relay is more of a pain when you've got good VHF with the other vehicle than it is anything else, because you end up getting a repeat on the voice. I recommend against MSFN relay when you can use direct VHF voice.

SCHMITT Yes, I agree. On the systems, I was surprised that the component lights in the test positions were very dim. But when they are activated by the caution and warning system, they are bright. I guess I never realized that before. Purely academic interest at this stage.

CERNAN The secondary glycol pump start up was, I recall, a somewhat ragged start up, as if the pump was slightly cavitating for about 15 seconds. Then it was smooth. There was no subsequent indication of the problem with the secondary loop because we didn't use it subsequently.

SCHMITT Referring to that radar test, it was the PGNCS turn on self test. I had a 400 in R-2 initially, and I had never seen that

SCHMITT (CONT'D) before in PGNCS turn on. That's what I was referring to about something different in the registers. It was on the initial PGNCS turn on, and self test.

CERNAN All the alinements went well. One thing that we discovered - the gimbals apparently were mistrimmed on the descent engine prior to lift-off. Someone is going to have to resolve whether that's true or not. The pitch and the yaw gimbal trim in the DAP were reversed as to our checklist. When I inquired about it, I found out that our checklist was correct, which gave me an impression that the gimbals were both mistrimmed. But they were so close to each other that the ground indicated we should press on and we should see no reaction to that mistrim, and to start up. We did and we did not see any indication of the mistrim. If pitch and yaw had been separated quite a bit, I'm sure we probably would have had to go through a retrim of the gimbals during the DPS throttle check.

SCHMITT One clarification comment with respect to the AGS. I mentioned yesterday that I thought it was a Z-gyro that indicated greater than spec calibration. It was the Z-gyro, just slightly greater, about 0.4.

9.0 SEPARATION THROUGH LM TOUCHDOWN

9.1 COMMAND MODULE

EVANS In optics tracking, I tracked RP-3 which is about 5 minutes prior to the subsolar point. And that's too close to the subsolar point to be doing any optics tracking. As soon as I got to the TCA on that thing, I completely lost the visibility of the landmark. So the only good marks on that are going to be prior to TCA.

CERNAN What was that landmark?

EVANS That was the landmark for updating the mapping camera film. Actually, it is a recalibration of those particular points that had been tracked on previous launches.

The circularization burn was a good burn. The only anomalous-type thing on that is that the residuals prior to trimming were plus 1.70 and minus 0.6. The minimum impulse is a 4-second burn. It underburned in the minimum-impulse case by 1.7 ft/sec. It turned out to be no problem. The ORDEAL worked as advertised throughout the flight.

9.2 LUNAR MODULE

CERNAN Prep for PDI - We just went out of the Activation Checklist into the Timeline Book. There are no notes concerning any anomalies. We stayed on the time line and as I said, we met the milestones with the ground. We came around the horn for PDI and established comm, and the ground had a load waiting for us. We had no NOUN 69 prior to P63.

SCHMITT We did have the communications problem prior to PDI. The thing that started it off was the ground started up-linking on the omni, which they had never done before in the sims that I remember, unless it was a situation where we hadn't gotten the steerable. They started on the omni. I was not watching that, and I switched out of the omni to the steerable in the middle of the up-link. That started the problem, which apparently was compounded, as I found out last night. Anyway, the Goldstone antenna went belly up somehow, and the men who talked to me last night still do not know how. Somebody may, and I'm sure it'll be worked out. The up-link did get in and all you had to do was proceed on the VERB 33. We did have a good up-link, and that whole thing was in there but nobody's quite sure how it actually got in there. The ground surprised us by coming up almost immediately with that up-link, which

SCHMITT (CONT'D) we've never seen before. In fact, I expected it would be quite late.

CERNAN We'd seen them come up fast, but they always waited for the steerable.

SCHMITT Yes. That's what caught me by surprise. At any rate, we got it in there and there was no subsequent problem. The comm thing did delay us, and we were running a little bit behind the time line.

Let me mention one thing on the DPS start which I didn't mention yesterday. And that is monitoring 471 in the AGS showed essentially no Delta-V accumulation in Y. That was a good idea, although it was unnecessary.

CERNAN As far as the start was concerned, the LMP confirmed ullage. I had my physiological cue, and I knew we had ullage. I was prepared to back up the ullage and back up the start, but we got an automatic performance in both.

SCHMITT It was very clear that the SHe tank had opened up within a few seconds. We got our first jump in pressure a lot sooner than I expected.

CERNAN All the pyro functions prior to PDI in the LM we could verify with a physiological cue. We could feel, and/or hear all of these functions.

SCHMITT And this was suited.

CERNAN In some cases, it was suited; not all.

I covered the performance of the engine. The PGNCS performed admirably. I called up the NOUNs I needed: 68s and 92s. We loaded NOUN 69s, and she just spit them out just like she always has.

SCHMITT The SHe pressures during descent held low. About 30 psi, as I recall, beneath the predicted number.

CERNAN NOUN 69 was plus 3400 feet, and that sounded very familiar, as I recall. Didn't we almost always in the sims have a plus? Even the nominal ones have a plus. Is that the problem they had? As it turns out, as soon as I pitched over, I took it right back out to get to our landing area.

SCHMITT Is that right?

CERNAN It was almost exactly the same number, which means that their targeting was essentially perfect, because the planned landing area was about at least a crater diameter short of Camelot.

CERNAN (CONT'D) That's where we pitched over and that's where we would have landed, which was the planned, targeted landing area.

We did not say anything about DOI-2. DOI-2 was slightly smaller than we'd seen in the past, because of the orbit degradation we were in. I think it went down to something like 11 miles, but the DOI-2 just went super. We got the residuals down to 00 and 0.1, something to that effect. We saw a 7.0 perilune out of the PGNCS and a 6.7 out of the AGS, which is exactly the type of' thing we expected. We went around to PDI in good shape. We got excellent radar and VHF ranging correlation during that radar checkout.

VHF Ranging and Radar Tracking - Everything was nominal during PDI right through pitchover. We got throttledown on time. We watched the computer and followed NOUN 92. The computer was happy, the GDC was happy, and everything was just perfect. At 13 000 feet, I could look over the edge of the window and see the South Massif. At 13 000 feet, I knew we were coming down in the valley because I could see the South Massif, and I could tell that we were in the valley or coming into it. At 13 000 feet, I had the impression we were level with the top of those mountains. (Laughter) I really did.

CERNAN (CONT'D) We pitched over, the needles dropped, pitchover occurred, 64, everything was nominal. Our target point was about a crater diameter short of Camelot. I used LPD frequently. I don't know how many times I used LPD, several clicks back, a couple left, a couple right. I just flew it where I wanted to fly it. I brought it back to an area in the vicinity and to the right of Poppy. As soon as I did that, I just sort of tumbled in on that area and did some more LPDs to finally what I'd call a suitable landing site. That suitable landing site became more evident the closer you got. Initial LPD changes to bring the landing site back east were just gross to change the area.

Once I had my area, I started tweaking it up to find what I considered a blockless and level area. I ended up taking over in P66 just a little below 300 feet. The reason I took over is that I wanted to slow our forward velocity down. I did not want to go any farther west, because there were more blocks and more hummocky terrain. As a result of all of our aft LPDing, we ended up (1) with a great deal more fuel than we might have anticipated, between 7 and 9 percent, I believe, and (2) the rate of descent, H-dot, was a little bit higher than normal, because of our steeper descent in the latter phases of the braking and landing. But as far as the CDR was

CERNAN (CONT'D) concerned, they were very comfortable rates of descent. The LMP passed them on and said they were a little higher. I knew where we were. I think the most significant part of the final phases from 500 feet down, as far as the CDR was concerned, was that it was extremely comfortable flying the bird, either LPDing in P64, and/or flying manually in P66. I contribute that primarily to the LLTV flying operations. That's why the rates of descent and what have you were just very comfortable.

I kept a good rate of descent down through 200 feet, slowed it down at a little bit over 100 feet to 1 or 2 feet per second, and then started it on down again. We started to get dust somewhere around 100 feet.

SCHMITT In my window, I didn't see dust until about 60 or 70 feet.

CERNAN The dust layer was so very thin that I could definitely see through it all the way down. It didn't hamper our operations at all. When I was satisfied that that was my landing site, I made sure we had between 1 and 3 feet per second on the crosspointer forward velocity, and to the best of my ability, zero left and right. We continued on down with about 3 feet per second to landing.

CERNAN (CONT'D) I saw the shadow come right on up to me, and this is very well done in the simulator. When it passed on under me, I was expecting a blue light. It seemed like it didn't quite come, when the shadow passed on under me for just a split second or two. We got the touchdown light. I had planned to say, "1 potato, 2" and then push the stop button. But I didn't. As soon as we got the touchdown light, I, like most everybody else, hit the stop button. Then things just went "plunk." We plunked down with a relatively good thud, I'd say.

Visibility through the final phase was excellent. The tendency, once you redefine your landing area, is to become a little bit less concerned with your peripheral landmarks out there, because you know now about where you're going to go. You get more tunnel vision, and you are concerned with finding these specific touchdown points within that landing area. That's effectively what I did. I had no Sun angle problems. At that point in time, estimation of distances didn't mean much, because I was concerned more with what was right down below me and in front of me.

I can't say enough for what I consider the accuracy of the guidance. Manual control of the spacecraft was hard and firm, different certainly than the command module operation but exactly what I expected the LM to be. The simulator, I think,

CERNAN (CONT'D) does an excellent job of controlling the firm good solid ATTITUDE HOLD, RATE COMMAND capabilities of the LM. I'd say that I touched down with about 1 to 3 ft/sec forward, and 0 left and right, and about 3 ft/sec down. We'll just have to find out what those numbers were. I don't know. The fuel remaining was between 7 and 9 percent. From the CDR's side, the systems were excellent.

10.0 LUNAR SURFACE

CERNAN Postlanding powerdown - We got the verb for STAY at T_1, T_2, but we got a GO for at least a T_3, and we started right through the checklist and the power on configuration. Based upon the review of the Surface Checklist, there were no anomalies in powering down the spacecraft. We just followed right on through.

PGNCS and AGS worked fine. Z, once again, had a higher than spec gyro count. It was nothing serious though.

Eat and rest period - We had an eat period on the surface. As we were beginning our EVA-1 prep, we took some pictures out the window. We just followed the checklist, and, all told, we ended up getting out some 30 minutes late. I'm not sure why.

SCHMITT Part of it was that P57.

CERNAN Oh, we had to do a P57 over because we reversed the marks on a spiral cursor, which was just an onboard problem on our part. So, we did the P57 over, and we lost several minutes. We sort of never lost any thereafter, but we never made them up either.

Suit doff and don - This will cover all the EV prep and post activities. We both found, LMP and CDR, that donning and doffing the suit in 1/6g was relatively easy. Once again, we

CERNAN (CONT'D) had no problems zipping up the suits. In the course of doffing, and prior to getting the suit fully off, we mutually lubricated each other's open zippers and all the connectors. When we doffed the suit, we went into a drying mode as the checklist suggests prior to the sleep period. I'm really glad we did because our suits stayed relatively fresh and clean on the inside. We doffed our LCGs every day and slept in CWGs rather than the LCG. And I'm glad we did that because it was much more comfortable. We made it a buddy system in the entire donning and prep when it came to the suit operations, except for putting on the gloves. We found it easier to put them on in parallel and get them locked and verified locked. We actually, each individually in almost all cases, put our own glove dust covers and ring dust covers on. Maybe we had to help each other once in a while. And contrary to some of our initial desires, we decided to go ahead and put those dust covers on for every EVA. After the first EVA, we found out what the dust problem really was.

SCHMITT One of the tabs on the LMP's dust covers did break off on the first prep.

CERNAN But besides that, we never used that donning lanyard that we had available. We never needed it. I can't really say anything else except that the doff and don went pretty much as we both

CERNAN (CONT'D) expected it to. We obviously took extreme care of our suits - the best we could - because we had to use them several times. I think that care paid off because even at the integrity check of the CM/EVA, the suits were tighter than a drum. I think the wrist connectors, even with the dust covers, were tending to get a little bit stiff.

SCHMITT Yes, mine were very stiff.

CERNAN But nothing ever really froze up on us.

LM vehicle systems operations - There weren't many systems operating during the lunar surface activities other than the EPS and the glycol system. We set it up per the Flight Plan. We updated the PGNCS periodically. It was all nominal operation.

10.1 FIRST EVA, MASSIF

CERNAN First EVA prep activities - And all I can say about the PLSS donning and checkout verification, cabin depress, communications checkout, and power transfers, is that it just followed the checklist and went nominally. The only thing that we might consider as a deviation is the fact that the CDR left his O_2 hoses off during most of the donnings because I felt I didn't need them with the water cooling from the spacecraft. It was easier to get them put out of the way early, and there was certainly adequate airflow. We left the flow on through

CERNAN (CONT'D) the hoses to keep circulation in the cabin during that time. I felt very comfortable and less contained by having those two hoses out of the way. All I had dragging from me was the water hose and the comm hose.

SCHMITT LMP wore the hoses most of the time to partly have a convenient place to put them. Also, I like the airflow.

CERNAN And they're more out of the way of the LMP because they're on your side.

EVA 1 - We just commenced the egress very slowly to get familiar, but basically there were no real problems with the egress. I felt you had to get down a little bit lower to the floor than I'd seen in the airplane, but once you understood where you had to get, getting out was no problem at all. Everybody knows that the LM cabin is very small, and you're restricted. You cannot move very fast or get out of each other's way very easily. So when you did have to turn your back to change valves or switches or circuit breakers, you had to move one at a time to get out of each other's way. Once we found out what those requirements were, we were able to work together very well and stay out of each others way most of the time.

SCHMITT Yes. Let me comment about the LMP's egress and ingress and general activities a little bit that I've done in the 1/6g airplane in the mockup. They seem to be more difficult and more constrained in the LM than they were in the airplane. I don't know exactly why. Part of it may have been in the pockets. I kept finding I was hanging my leg pockets up on those things. I don't remember whether I had those on in the airplane or not.

CERNAN The key to ingress was to get all the way in and then bend my legs up. As soon as I bent my legs up, all of a sudden everything broke free. I think it was that the pockets were hanging out on the sill, and as soon as I bent my knees, it took the pockets off the sill, and I just slipped right in. I didn't learn that until the second egress. Work on the platform and on the porch was fine. We got the MESA deployed. The LMP egressed, We got the LRV deployed.

SCHMITT Cosmic ray was deployed nominally. LM description and plan - There wasn't much to say. I had the impression maybe the strut was stroked, but that was discussed and photographed.

CERNAN The whole EVA, as we call it, "closein," went so close to our EVA closeins and eventually closeouts at the Cape that even I was amazed. It turned out that I got to the flag just about the time I always got to the flag, and you were ready. It just couldn't have been a better reproduction of the training

CERNAN (CONT'D) activities at the Cape. I think the transcript and the television better describes and debriefs that portion of the EVAs than we could by just sitting here and saying everything went nominal by the checklist because that's essentially what happened.

SCHMITT You've heard all about the ALSEPs and the LTG problem in real time. It's on the transcript. It was something in the dome removal strip. We pried it off with a hammer. The ALSEP traverse surprised me in that the package seemed heavier than I had expected.

CERNAN You lost a block.

SCHMITT I lost a block. It just came off the Velcro. I may have hit it with my leg. Really the dust was so deep and soft that the blocks were relatively ineffective, and I ended up putting a rock underneath one corner.

ALSEP deploy - In the LMP's point of view, it was slower than I expected it to be. But, everything got deployed. And, the geophones were faster as we expected.

CERNAN The heat flow went very well. It just went bang, bang, bang. Really the only difficult thing in 1/6g is that fact that you cannot bend over very easily to pick things up. I used the

CERNAN (CONT'D) drill for a brace almost every time I had to get the wrench off, as you saw and heard in the transcript and pictures. Every time I found out that I reduced a work output and reduced the frustration when I set the drill in the right place, leaned on it, and took the wrench off. The only little thing I had some problems with was with the core and the bore; you have trouble in 1/6g with the gloves on to aline the threads and make sure they get all the way seated on the following bore or core prior to starting to drill. I had a couple of problems with that, but eventually I got them all. I never rammed a thread down with the drill. I always had it all the way flush, which preserved the bores, of course. The whole operation just went well. You saw it; you heard it. We followed the procedures. The TGE could have been taken on and off very easily on the Rover. The only thing that we didn't anticipate about taking readings when it was off the Rover was again the same problem. You have to lean down to get to anything, and the TGE is very low. It's very difficult to get down there and make anything but a swipe at the buttons when it's on the surface. I'm very glad we did not have to take it off the surface for all the readings because it made it much more convenient. It was not a problem of taking it on and off. It was a problem of pushing the button once it was on the surface.

SCHMITT The ALSEP photos were not taken in the normal way, I think that by the time we had finished our second and last traditional revisit of the ALSEP, a fairly good collection of photos had been obtained, both on specific request from the MOCR and also random photos I took while they were thinking.

CERNAN The whole EVA-1, all the way through the station 1 activities and the SEP deploy, although there were modifications in it, followed the checklist. The best debriefing is the transcript and the TV. I don't think there's anything we can really add to that or any of the other particular stations that hasn't already been said in real time.

SCHMITT Let me mention again, for the record, that the geophone module package did not constrain the geophone's lines very well. But the net result was a good triangular deployment of geophones, even though they are not anchored at the base of that triangle.

CERNAN We go into ingress and the EVA closeout was again pretty much as planned without anything worth talking about other than what was heard and seen.

SCHMITT I don't know whether you've been told yet or not, but both the SRCs have excellent backings.

CERNAN Good.

SCHMITT Number 2 has the best they ever had.

CERNAN I took pains to make sure that that thing was sealed. They did have excellent backings? That's good.

EVA post-activities - Again, the refurbishing of the PLSSs went as was written in the checklist, both with, oxygen and water. Apparently, we got them completely refurbished for every EVA because the total time we were able to accumulate on them in the second and third EVAs. I never had any problems throwing the CDR's PLSS back in the recharge station.

SCHMITT Let me go back to the EVA closeout. The transfer of the gear up the ladder by hand was not difficult, but it was more difficult than I had expected. Getting the EVA pallet in ahead of me looked like it might be a problem, but I found that by pushing the hatch full open and putting the pallet off to the right, I still had plenty of room to move around. I put it to the right, next to your stowage area, and it was out of the way. I got in and then reached over and undid it. Taking the gear off the pallet took longer than it did in training. It was a more difficult job.

CERNAN That whole transfer seem to go very well, the transfer into the cabin and transfer back out of the cabin.

SCHMITT Tool management reminded me of that for some reason the left-hand pocket down low on the left leg was essentially not used. I couldn't get to it easily. I was able to get to the right pocket and I did stow odds and ends of samples in there occasionally, and once or twice, the hammer. In general, it was only the right-hand pocket that was useful to me. Tool management was as we had trained, with the exception that as the EVA's progressed, the spring-loaded latch that locks the scoop into a given position in the detent ceased to function very well.

CERNAN EVA post activities - You got anything to add?

SCHMITT We did that in parallel with other activities.

CERNAN We approached that relatively casually but with the idea of getting to bed on time, and for the most part, I think we had a little fat in there. Where we didn't we still preserved the 8-hour sleep period because the next day was not necessarily critical, except the day of launch, on which we wanted to get up on time.

Performance comments, equipment - I cannot say enough for the PLSS operation. Cooling capability was there tight as a drum; communications were excellent; and the suit performed well.

SCHMITT The only problem we both had was in the gloves. Just general fatigue and also continual pressure against the nail there bruised under the nails.

CERNAN That pressure against the nail areas was not a pressure caused by short gloves for me. It was just because of use. You required so much dexterity during the ALSEP deploy that it was apparently a pressure that got you across the top of the hands or the top of the fingers, but it was not a fore and aft pressure for me.

SCHMITT But you still got some bruises under your nail? I don't see my other way to get that but by pushing against the nail. There was no way to avoid it either.

10.2 SECOND EVA, SOUTH MASSIF

CERNAN Here again, you can talk about the prep activities. We were obviously smarter. Some of the things you do in EVA-1 do not have to be done during EVA-2 because they're only done once in terms of stowage and what have you. We had some OJT on EVA-1, and EVA-2 just went right down the line. We got the cabin depressed, got out, and went to work. I cannot say anything about EVA-2 egress or equipment transfer or anything else.

SCHMITT Yes. I don't want to waste time on the traverses because I plan to do that with the tapes.

CERNAN I've talked about Rover mobility and capability and the requirements of the driver for continuous attention and that became very evident on EVA-2.

SCHMITT Although I made reference to most of the little memory jogs we had in the Cuff Checklist, it turned out they were not specifically necessary to have them in the checklist since our continuous observation and discussion of the surface covered those things as a matter of course, if they were there. I think the most important thing that they did was to force us to review cuff checklists prelaunch to learn, train, and think about the kind of problems they were referenced to. In the actual operation, most of those discussions took place relatively automatically.

CERNAN The CDR's navigation page used in traversing to each station was probably one of the most useful things I carried on my cuff checklist. It kept me very much aware of the general heading I had to go and general large features we were looking for, I just think it was extremely useful. Because of the terrain and the inability to travel on a straight line for very long periods of time, I primarily did not navigate on heading. I primarily navigated to a point. And so the particular points that were shown for jogs in the traverse, or for Rover samples, or charge deploys, or for stations were most

CERNAN (CONT'D) valuable to me, because I navigated to a range and a bearing and didn't worry particularly about the exact heading. That seemed to work out very well. And that's why we never, on any of the three EVAs, followed our tracks back to anywhere. We crossed our tracks a couple of times but we never covered the same piece of real estate twice. Performance of all equipment after EVA-2 was excellent. Going into the EVA-3, the prep, again, was familiar.

10.3 THIRD EVA, NORTH MASSIF

SCHMITT Station 3 - We both did most of that station separately. Gene was working the double core as planned and I was doing sampling. I got a little inefficient at the start because I didn't have a bag to put samples in. Once I got a bag, it was a little hard to handle because I was on a side slope. But in the time that we spent there, I think it turned out that Gene got an excellent double core canned and I got on the order of 10 or 11 documented samples, both surface and trench samples at the edge of that crater. I would still have a hard time evaluating now whether we could have operated more efficiently together or separate in that particular case.

CERNAN EVA-3 closeout was nominal. It was modified because the LMP had to go back to the ALSEP again, As far as I'm concerned,

CERNAN (CONT'D) the recovery of the neutron flux, parking the Rover, turning off the SEP and going through all that worked very well. Here again, any modifications to those closeouts are really not bad at all because we used the checklist as a reference and not as a cookbook. We understood what had to be done and what had to be closed out *so* that we could accept modifications and also pick up each other's task. And we did that quite frequently on the closeouts. We could see what the other guy was doing, and picking up the other guy's task occasionally, when you had a free moment or an easier reach, was a very simple thing to do. That comes from having done this together many, many times. Probably the most difficult job of all the closeouts was trying to dust the suits. It's a difficult and awkward position. It's hard to make fast sweeping movements in a stiff suit. We did our best, and I think probably the time spent was well spent. But I think also it was a bit more time than we had anticipated. The real-time transcripts will show just how much time and effort was spent in dusting. Both of us found that our lower limbs and boots could probably be better dusted by jumping up and down on a ladder or clapping your feet together on a ladder, which, incidentally, the CDR had to do in every case because he was the last one in. His feet were always in the dust prior to getting on the ladder. But I think that worked out pretty well.

SCHMITT (CONT'D) Third EVA was pretty much operationally like the second. We worked on slopes on both EVAs. On the third we did have the Rover on the slope. That didn't seriously perturbate the operations. I intended to rake larger areas for samples than I had planned to, but that was mainly because we weren't getting very many samples per rake swipe in most places. I think the only place we got a large number of samples was at station 1. After that we were dealing with no more than 10 in raking over a very large area in any of the other rake samples. But that's clearly documented in the samples. I don't know how many LRV samples we actually took, but it wasn't a problem. And the sampler was used whenever I worked around the LM or went out to the ALSEP or anything. As a result, I picked up maybe a half a dozen more samples just because it gave me something to carry a sample in.

CERNAN The only piece of hardware I remember that broke was the bag fastener on your camera.

SCHMITT Somehow or another I strained that and I taped it on in the cabin between EVA-2 and EVA-3. That taping job, using the food-pack tape, worked very well. We had no further problems. The EVA-3 post comments are the same.

SCHMITT (CONT'D) Equipment jettison went smoothly with no problems. You had the feeling that if you had an infinite amount of oxygen and water, you could have used those PLSSs indefinitely. Good systems.

CERNAN In closing, as obvious and as always true in the past, the efforts put forth on the surface of the Moon, or any place else, are based upon a great deal of work by a lot of other people. In general, the most significant group of people that supported us in excellent fashion, and probably the best I've ever been associated with, is our team led by Dave Ballard. Those guys continually went out of their way to make sure that things were done right. I just can't say too much for the effort that they expended. They performed in a super professional manner. Without that team and the training, the debriefing that we've just gone over here for the last 2 days might be a lot different. The success of Apollo 17 is due to a lot of people. In particular, the LM activities went so smooth. The LM stowage, in which there were a few changes right at the end, the interior cockpit stowage and the exterior descent stage stowage, was really in outstanding shape, and it was due in no small part to the efforts of Terry Neal. Terry's had a great deal of experience in the past on previous flights, and that experience really showed itself. He was a tireless worker. He supported every activity without being asked to at the pad, and came back

CERNAN (CONT'D) and told us what he had to support. He kept us informed. He made sure that people who were in charge and responsible for all the training gear had all the knowledge to keep it up to speed, based upon flight configuration of gear. He was concerned about the type of details and things that the crew is either too busy to handle or certainly would have let slip by. He's the guy that got the job done for us so that when we got up there, to unstow the gear and to put it to work, it was not only like we had planned it to be, but it was all there and it was properly and professionally done.

SCHMITT Your statements are certainly echoed in my mind with respect to the entire team. Every time something needed to be done there was somebody there who had already done it, generally. It wasn't a question of asking. It was a question of doing, or of utilizing the results of the team's effort. Terry Neal certainly made the lunar surface stowage and equipment operation, both in flight and in training, outstanding. There is no other word for it. We had no difficulty at all in learning where the equipment was and how to use it in its storage locations. I'd also like to congratulate the EVA operations group for their work in putting together three, very complex Cuff Checklists, and in keeping a general trend of training going that was just about at the right level. We reviewed the various EVAs in a reasonable sequence. And by the time we

SCHMITT (CONT'D) launched, I think we had enough of a feeling for what was in the cuff checklists that we really, as you said earlier, only used them in the review and that can't be to anybody's credit but the people who organize the training program.

CERNAN And the entire support team - it wasn't a case of them keeping up with us getting ready for the flight, but a case of Us keeping up with them. Because they were going to be ready for the flight and they made it a point of making sure that we were going to be ready also.

SCHMITT I think it's also worth mentioning that we have nothing to give but praise for the ability of the suit technicians not only to keep our gear in working order and up to date with the changes that might be coming along, but also in training us on how to use the gear. That is perhaps not in their job description. No small part of our ability to get in and out of the suits, and understand what you can do and can't do with the suits, in terms of doffing and donning, goes to the four guys who were our suit technicians.

11.0 CSM CIRCUMLUNAR OPERATIONS

EVANS Operation of the spacecraft - The CSM solo operations are essentially nominal. One time on the back side of the Moon, after I'd done the zodiacal light, where you had to switch to CMC free during the pass to prevent any jett fires and then you switch back to auto, I missed the switch back to auto and proceeded on into the waste-water dump and urine dump. Unfortunately, I locked the spacecraft control switch and CMC free. The waste-water dump evidently puts in quite a torquing force or perturbates the spacecraft such that I was getting a master alarm with the gimbal lock light. As soon as I had the caution and warning, I checked back and found that it was getting close to gimbal lock. I switched to SCS, and it backed away from gimbal lock. Then I pushed back to auto and got back to P20 attitude.

Navigation, normal state vector updates - When the down range error got to about *30* 000 feet, I let go and shifted up a state vector. The RQ model being used over in mission control to project the orbital decay didn't work quite right, so I ended up with the orbit not decaying down to the circular orbit prior to the plane-change burn. I ended up making the high adjust maneuver or trim burn to bring the orbit down to *63* by *63*. The trim burn was performed about an hour before

EVANS (CONT'D) the plane-change burn. Trim burn was a 9-foot-per-second RCS burn.

LM acquisition - Nominal in all respects. The thing that is somewhat of a surprise to me, and I should know this, you get molded into a false sense of security by doing rendezvous in the CMS. You look through the telescope, and there's a big blob of light. The telescope is indicating where the LM is. In the real world you look in the telescope, and you can't see. It's very hard to see 150 miles away. As a matter of fact, the LM was at about 80 miles before I actually saw the flashing light in the telescope. As I went into darkness, I could see the flashing lights in the sextant. I did not get LM acquisition prior to going into darkness, and I did not have it in the first part of the rendezvous. I did riot have the Sun in the sextant. There was no Sun in the telescope, and it was about 3 minutes prior to spacecraft sunset before I had the Sun in the sextant and in the telescope. I could not pick up the LM in either the sextant or the telescope. Once I had picked the LM up in the sextant, I had no problem from then on.

Update pad and alinements - No problem. We kept the P30 pad in R-11 where it was always available in case I needed it. I always realined to different REFSMMAT. In translunar coast

EVANS (CONT'D) or transearth coast, I always switched to SCS minimum dead band and gyro torqued. As I picked stars on the dark side of the Moon, I would coarse aline to the new REFSMMAT. It might be interesting to note that on PDI day prior to LM separation, there's a P52 scheduled about the same time the LM crew is getting suited up. I delayed the P52 until they were in the Challenger. By this time, the SEP attitude pointed the optics right down to the Moon. The PICAPAR didn't work, so I just started the spacecraft roll and kept recycling the 404 alarm until I finally was able to get it to work. After I got to P52, I maneuvered back to the LM sep attitude.

Lunar sounder boom deployed - We had a little test to extend and retract the booms. Extend worked okay. Retract and HF 1 never did get the gray. The antenna retracted to the extent that there was no problem for RCS or SPS burns. In trying to retract prior to plane change, we looked out the window and could see it start back in. The extensions on HF 2 - Number 1 always extended all right, but number 2 would go out for a little way and stall. We retracted it for 5 or 10 seconds and then switched it back to extend until it deployed fully. At any rate, with a little bit of work, we got the booms in and out.

EVANS (CONT'D) Monitoring lunar activity - I did not attempt to monitor it but I could put on VHF and talk to them. I was usually operating during VOX during the solar periods, so I just left the VHF off. Prior to lift-off, we had MSFN relays activated that worked real fine.

Lunar sounder pad experiment - No problems. Everything worked fine.

SIM bay daily operations - On the mapping camera, the first extension took longer than anticipated, so it was elected to leave the camera extended throughout that day. It took about 4 minutes to retract when we retracted it. On one of the mapping camera oblique passes where we were starting at the spacecraft sunrise terminator, I went to operate and got the barber pole. The Malfunction Procedure is to go to standby, which we did. We left it in standby until we just about came up to AOS. At that time, the barber pole disappeared. Evidently it was caused by the mapping camera area being too cool. And as soon as I got the gray indication, I went to operate and had no problems the rest of the time.

Laser altimeter - It seemed to work fine. There were no anomalies.

EVANS (CONT'D) Pan camera - There were no anomalies that I know of with the pan camera. There was some concern at one time if it was getting a little warm in there and also some concern as to whether the lens had really stowed.

UV spectrometer - As far as I know, we got outstanding data. The information that was passed up to me indicated that there isn't as much hydrogen in the atmosphere around the Moon as was originally thought.

IR scanning radiometer - It worked real fine. We're still getting good information, and we were getting good information on the way back. It was on most of the time.

The SIM bay photos - Let's see, that means photographs by the LM. It seemed to work all right. The Challenger was easily maneuvered around to the right viewing attitude. They got some good pictures. Sunlight was okay.

Dim light photography - The dim light photography was the zodiacal light and the solar corona. It was okay.

Terminator photos - Hopefully, those are going to come out. I used a lot of Nikon film for terminator photos. We should have a lot of 35 mm stuff that was not planned or not scheduled in the Flight Plan. We used the Nikon with a red filter and a

EVANS (CONT'D) blue filter and took three shots with the red filter and three different shots with the blue filter of the landing site area. We also used two different polarizing filters in one direction and then in the other direction. That information should be in the Flight Plan. In each case, the zodiacal light with the filters worked out real fine. The timing and the settings worked correctly. I've got it noted in the experiment checklist that I had the wrong setting for half a second. I ended up on the 1-second mode. I think that was in the polarizing part. In any event those pictures should be good. In sketching the zodiacal light as you come up to the spacecraft sunrise, I think we probably didn't get the longest streamers that are just half a second or quarter of a second prior to the Sun popping over the horizon. In each case of the zodiacal light passes, the sequence ended 7 to 10 seconds prior to spacecraft sunrise. I think we probably missed the longest streamers. I didn't really observe this phenomena until the last day of lunar orbit and didn't have the opportunity to take a hand-held target of that particular phenomena.

Solar corona - The sequence worked real fine, no problems.

Earthshine photography - We worked it differently than it is indicated in the experiment checklist. I used Aristoteles and Copernicus starting out with a 1 second and taking two

EVANS (CONT'D) 1-second exposures. As we rotated around about every 30 seconds, it ended up a little closer than I thought. We were passing up the target too fast because we'd never get everything. The timing sequence may not be correct. It may not be exactly 30 seconds between each one. We would cycle down the exposure setting to 1 second, 1/2 second, 1/4 second, 1/8 second, and 1/16 second on Aristoteles and Copernicus. We'd leave it on one-sixteenth of a second following Copernicus and switch over to window three and pick up Reiner Gamma and do the same type of sequence. Then we stopped on 1/8-second exposure and carried it out until the end of the film mag.

Orbital science photography - It worked according to the Flight Plan. We would have the initial setting, and on the orbital monitor charts, we would have the inpoints and then pick out specific craters and have these noted on the chart as to change settings. I did notice that it is very easy to bump and change the camera settings as you bounce around in the spacecraft - trying to keep track of the camera pointing as you try to maintain your own equilibrium. A couple of times at the end of a particular sequence, I noted that it had changed from what I had started with. The orbital science photography was accomplished with no particular problems other than trying

EVANS (CONT'D) to maintain a constant camera setting. We had two magazines of what we call CM option or option-photography colored film. Those two magazines were completely filled up with just targets of opportunity.

Plane change 1 - I previously mentioned the trim burn part of plane change 1. Plane change 1 was a little larger than anticipated because of nondecay of orbit, Plane change 1 is where I had 0.7 ft/sec and it seems to me like an X. I did not trim it because we were only trimming Y. There was also a plane change where I ended up with a different roll because the pan camera was looking right into the Sun. No real problem. If I were going to trim anything, I would trim Y and Z just to make sure I didn't perturbate the apogee and perigee orbit. To keep the pan camera out of the Sun, I went into P40 trim and utilized that roll angle. Communications were outstanding. Maneuvers done to support the lift-off presented no problem.

Rest and eat periods - I never got to sleep on time. It just took a great amount of time for one man to go through that Presleep Checklist - to go down and chlorinate the water, take the panel off, pull the return valve and clean the hoses - it just takes a lot of time to get it all done. But, there's no real problem.

EVANS (CONT'D) TPI backup - My TPI solution agreed quite well with the Challenger, no problem.

Midcourse backups - I ran into a bit of a problem. I ended up with 5 ft/sec as a Z-value, and the LM ended up with 1 ft/sec. I don't understand why there's that much difference between the two midcourse solutions. Of course, the Challenger made all the burns during rendezvous and braking, so I didn't have any problems there.

Prep for docking - There is no time to get all the cameras and things squared away prior to going into rendezvous, so I strapped the TV monitor to the XX strut by the CDR's couch and utilized it during the rendezvous and braking phase or final phase of the burn. I used a P79 to point the X-axis out the LM. And once it got close, I essentially pointed the spacecraft such that the LM was always in the center of the TV field of view while coming in for docking.

LIFT-OFF RENDEZVOUS AND DOCKING

CERNAN LM powerup and launch preparation went well. We did not do the P22. Everything else just went *as* advertised on the LM. She powered up beautifully. The lift-off was normal. Obviously, we got all our pyros, and we lost no changeover, Parker valves, or anything. Very soon after lift-off, we had apparent loss of comm, a lot of noise in the S-band. It turned out that we were down-linking, but there was something wrong with the up-link. So the CDR watched most of the guidance and would call out, in the blind, altitudes and GOs and what have you as we pitched over and pressed on up. For about the first 2 or 3 minutes, the lunar module pilot had to concern himself with trying to get comm back.

SCHMITT Apparently, Goldstone dropped the up-link. When they were getting it back, I was switching omnis, and for a while there, it was just completely out of phase. They had a continuous down-link on us.

CERNAN It was a very inopportune time, I might say, because it happened just right after ignition. I think that's something, though, that the INCOs are going to be able to clarify. We certainly can't give you the details. It's just that there was essentially no comm on all the antennas.

CERNAN (CONT'D) We flew into a trajectory that appeared to be nominal. The AGS showed us slightly out of plane. As a result, our tweak at 9 ft/sec was minus 4, minus 9, and plus 1. We burned out X, Z, Y, in that order.

SCHMITT It was about 7 ft/sec, a little over 7 ft/sec.

CERNAN it looked like we might have had a g-sensitive drift in our Y-accelerometer in the PGNCS. The tweak was excellent because our rendezvous was just as nominal a rendezvous and as nominal a trajectory profile as I've ever been involved with. The drift in accelerometer did not bother us anywhere else in the tracking or in the rendezvous at all.

Rendezvous navigation followed the checklist; we got right off the form very well. We got all the updates into the AGS. The residuals in the TPI burn were greater than what I had expected. We did *not* record them because I wanted to get them nulled out just as soon as possible. I don't know the tenths, but they were minus 7 in X, and they were 4 and 4, and I'm not sure whether they were plus or minus in Y and Z. They were large, larger than I'd expected. They were minus 7 and 4-point something and a 4-point something. We reduced those to less than 0.2 ft/sec. From then on, we continued to plot right through the midcourses right up the pike on a nominal trajectory.

SCHMITT The comm was good. I have a couple of comments about the AGS. Early after insertion, I always checked the accelerometer. They looked real good. About 5 or 10 minutes later (I can't remember exactly), I looked and I'd accumulated maybe a foot and a half per second in X. I did a gyro cal, and after that, there was no significant accumulation in X. It went very well. I did that without talking to the ground, but I felt I had an understanding with them on that.

On the TPI solution, the AGS was essentially within 2 or 3 ft/sec, a good TPI solution after six marks. The insertion solution was not very good. It was off by a number of feet per second in X and even more in Z. This was the first one of 17 marks. The PGNCS recycle and PGNCS final were very close, within a couple of feet per second.

CERNAN Midcourse Solutions - The first midcourse solution agreed effectively all systems, except AGS out of plane was a little bit high. The decision was made to burn the onboard PGNCS solution out of the LM, which was minus 1.2, plus 0.4, and plus 0.3. We continued to track right up the pike. Midcourse 2 came up, and we again prepared all the solutions. The AGS out of plane was still a little bit high and actually in the opposite direction from the PGNCS. We had a slight variation in the CSM solution in Z. I don't know why. It came up with

CERNAN (CONT'D) plus 5.4 ft/sec in Z. So we really didn't get a very good correlation between the CSM and the LM on the second midcourse. But the PGNCS was still performing, the radar was still performing, and based upon our trajectory plot and based upon our following a nominal inertial line of sight rate, we decided to burn the onboard PGNCS solution in the LM. It was minus 0.4, minus 0.7, and minus 1.6. From there on out, we just continued to follow the inertial line of sight angles. There was very little tweaking in either Y or Z. We just sort of floated right through the braking gates. At 1 mile, I think we took about 6 or 7 ft/sec off to hit 30. We met all the gates as prescribed and just came moving very slowly into the final stationkeeping. We went into a formation flight around the CSM. We got a good inspection of the spacecraft and the SIM bay, the report of which is in the transcript. Everything looked good to us. The command module maneuvered to the docking attitude. The LM just took its docking attitude, gave stationkeeping control to the command module, did pitch and yaw maneuvers, and stood by for docking.

EVANS One of the noticeable differences between this docking and the docking with the S-IVB is the fact that the ascent stage did dance a lot more than the S-IVB did. The S-IVB is steady as a rock. The LM dead band would change attitude, and you'd try to

EVANS (CONT'D) follow it. On the first attempt, I must have had less than 0.1 ft/sec, just barely closing. I was just taking it nice and easy. We made contact and did not get capture. As soon as we didn't get capture, it was obvious we were closing too slowly. We backed off a couple or 3 feet, renulled the rates, initiated the closing rates, and got capture, As soon as we got capture, both vehicles went to CMC FREE. I looked out, and I had some rates in the CSM and I'm sure that the LM had rates also. He must have had.

CERNAN We went FREE. Upon capture, the LM went FREE. The CSM trying to null the rates ended up perturbating the LM and giving us rates.

EVANS We finally gave up on that mode and had the LM go to ATTITUDE HOLD. Once you get ATTITUDE HOLD, the CSM could null the rates. We got it lined up and attempted the hard docking. There was no problem. The probe retract came back. This time, it didn't sound like it was as much of a ripple fire. It was more of a "phhtt." It was a quicker hard dock than it was the previous time.

CERNAN I want to say something about the visual sighting during rendezvous. From the LM, I was able to see the command module when it was sunlit at somewhere around 100 miles. I definitely defined that that was the command module. After the command

CERNAN (CONT'D) module went into darkness, I could not pick up his tracking lights until we were well within about 40 miles. I could not pick up the docking light, the rendezvous light, of the command module until we were well within 40 miles. It was initially a very dim, faint flash. I was able to verify on board that the LM tracking light was working. I finally figured out how; it was reflecting off the underside of the EVA handrail on the left forward side of the LM. I could see the LM tracking light flashing. There were some particles we took with us that stayed with the spacecraft, and you could see the sequential flash off the particles as the result of our LM tracking light.

SCHMITT Regarding the television and photography from the LM, we'll just have to wait and see how it turned out. I took a lot of footage. We put it on not only the ascent mag, but we put it on the other mag. That includes the SIM bay. Right or wrong, we did have a Hasselblad on board, so we have a lot of Hasselblad photography.

13.0 LUNAR MODULE JETTISON THROUGH TEI

CERNAN Postdocking Check and Pressurization - The general comment I want to make about the postdocking operations is that both pilots in the LM took their helmets off to keep the dust off, primarily. The commander took off his gloves almost immediately after insertion, and flew the entire rendezvous that way. Jack took his off some time later.

SCHMITT I kept mine on for some time. I can't remember exactly when I took them off. I did most of my preinsertion work with the gloves on, because I didn't want to take the time. I wanted to get that initial AGS solution. I could get that fairly rapidly with the gloves. I didn't take the gloves off until maybe 10 or 15 minutes after insertion. I kept the helmet on all the way through most of the transfer, just to avoid breathing the dust. I had the sinus irritation on the surface.

CERNAN The commander kept his helmet on throughout the rendezvous and docking. I took my gloves off after insertion and left them off. As soon as we were hard docked, the commander took off his helmet. As I look back at that, because of the dust debris in the LM spacecraft, I'm sorry I did. I could have left the helmet on, and I would have had a lot less eye and mouth type of irritation. You knew you were in a very heavily infiltrated atmosphere in the LM because of the lunar dust. I don't know

CERNAN (CONT'D) how much lunar dust previous flights had, but I think we saved a great deal of grief by sweeping all the dust we could find on the floor into the holes and putting our tape covers over those holes. I think that had to help a great deal. There was an awful lot of dust on the floor that we didn't see.

The commander had his helmet and gloves off all throughout the entire transfer. We handled the transfer the way we'd planned. The LM pilot did most of the preparation of the gear in the LM, and the commander stayed in the tunnel and passed things on. The inventory was going on in the command module side and on the LM side, both. We vacuumed each other's suits the best we could and everything else that got supposedly transferred, unbagged, or uncovered.

SCHMITT In spite of the CMP's comments to the contrary, I think we got things remarkably clean. "here wasn't an awful lot of dirt in the command module coming back.

EVANS That's true.

SCHMITT In contrast, he may have thought it was dirty, but I was surprised we were able to keep the level of contamination in tne command module down.

CERNAN After I took my helmet off, I could go halfway through the tunnel and stick *my* head up in the command module, and it was a

CERNAN (CONT'D) totally refreshed, unpolluted atmosphere up there. It never did get polluted.

SCHMITT I think having that vacuum cleaner running in the LM had a lot to do with keeping the flow in the other direction, filtering out the air.

EVANS We never did vacuum in the command module because it just wasn't necessary.

SCHMITT The suits were noticeably cleaned by the vacuum cleaner. You could tell you were pulling stuff off them, although they were still dirty. Every subsequent time we handled them, we got our hands dirty. I think most of the free dust was taken care of.

CERNAN We effectively stayed on the transfer list. I *say* effectively, throughout the transfer. However, some things got transferred out of order and temporarily stowed in the command module. We effectively used the transfer list not as a cookbook recipe type of thing, but as an inventory list. We inventoried it several times from both ends and were satisfied we had everything transferred. We then pressed on with the LM closeout.

The LM closeout went nominal. We got back into the command module, and the LMP closed out the LM. For convenience, the commander went back and closed out the LM hatch and put in the command module hatch. Because of the slow tunnel vent, or the

CERNAN (CONT'D) long duration of tunnel vent, the commander stayed in the tunnel, the LMP in his seat, and the CMP in the left seat. We suited up and prepared for our integrity check. As soon as the LM tunnel vent was complete and we were satisfied with the integrity of the hatch, we went into the suit integrity check.

EVANS I bet it must take at least three or four times longer than the simulator did for the tunnel vent.

CERNAN I think that's going to be applicable to Skylab. They're going to have to vent before they undock, I think.

The tunnel closeout was easy. We had no drogue and probe which were stored in the LM for LM jett. We just followed the checklist, and it all seemed to happen just as advertised.

EVANS We got a little bit intrigued with the LM jettison. It was great. It just sailed out there nice and pretty, and we got a lot of good pictures of it. We should have been maneuvering. We ended up getting into P41 after jettison for sep burn, a little bit late. That was no problem either, because we just trimmed the residuals for P41 and got a good sep burn.

CERNAN Cleaning control in the command module was excellent, considering all the dust and dirt that just seemed to adhere to everything in the LM. When we got back in the command module, with the exception of the suits, and LMP and CDR, everything was

CERNAN (CONT'D) clean. Everything was clean because everything was bagged before we brought it over - bagged and zipped. We never did open anything once we got it zipped up. So the command module stayed exceptionally clean throughout the remainder of the flight.

SCHMITT In the bagging of the decontamination bags, I made a special effort, after requests prelaunch, to pull those zippers as tight as I could. They should be pretty tight.

EVANS High gain always worked good; omnis and S-band were good. Photography went as advertised. We had lots of targets of opportunity. SIM bay operations have been mentioned before.

TEI updates, normal. Sextant star checks were good for TEI.

CERNAN Every one all through the flight was good, which made me feel real good. I made sure I got it on those last few. I wasn't going to change any mode of operation. I made sure I got it on TEI. Just to make you guys feel at home. I figured you'd think I didn't do it right, if I didn't get the master alarm.

SCHMITT *The* TEI, at 1/2g, or whatever we were pulling there, seemed like more than that.

EVANS It sure did; it seemed like it was really pushing you back in the seat.

SCHMITT Ron and I both started out holding our heads up and eventually relaxed them back on the couch.

CERNAN I guess we must have had the spacecraft pretty well stowed, or tied down. I briefed the CMP and LMP, and, as I recall, those kind of burns back on Apollo 10, lots of things start moving through the spacecraft and find their way to the aft end of the spacecraft because of the g-load. Much to *my* surprise, all we had was an initial thud as we moved away from the station, and we didn't have any gear flying through the spacecraft.

SCHMITT I found a white tag, wetwipe.

CERNAN Other than maybe one or two of those things, in looking back, I would have expected more gear to come from somewhere, but we prepared for those burns pretty well.

EVANS That reminds me of **all** this water condensing on the ECU unit, the pipes, and what have you. When we put our suits on for the EVA the next day, your suits were noticeably wet. When I pulled the PGA bag up, **it** was damp down underneath the PGA bag. As a normal procedure, we should have, either after the burn, probably before the burn, made sure we wiped up the water in the LEB.

CERNAN Our suits were damp when we put them on, but I could not find any real water down there.

EVANS There's always water down there in the ECS. I just assumed that's where all of it came from. There's not a puddle of water. Like I said, it's just damp.

CERNAN It's almost as if it was colder down in the LEB, and water was condensing all over the suits. It wasn't as if they were in a puddle.

EVANS The simulator is set up such that in roll dead band, it goes over to one side of roll dead band and just kind of stays there. During the TEI burn, it was bouncing back and forth from one side of the dead band clear over to the other side of the dead band. When it's bouncing back and forth, the roll rate is up around, oh, 0.4" per second, arcing back and forth across the roll dead band.

I'd like to mention chlorination at this point.

CERNAN Without fail, almost every chlorination leaked. Sometimes large quantities of water, other times just small quantities of water.

EVANS Water or chlorine?

CERNAN A combination. Where it leaked appeared to be around the bag. It was the cylindrical chlorine dispenser that was continually wet. It was not where the dispenser fit into the needle or

CERNAN (CONT'D) where the needle adaptor fit into the spacecraft. It was within the chlorine dispenser itself. Chlorination was a case of always cleaning your hands with chlorine because you always had it available down there within that dispenser. In some cases, you had a larger quantity of water that had to be wiped up with a tissue. That plagued us throughout the whole mission. It turned out not to be a serious problem because we learned how to handle it. That was one system anomaly that hadn't really been brought up.

EVANS In two cases, I'm almost positive, it did not puncture the ampule. The reason I believe that's correct is that, when you started to crank the outside of the cassette down to push the chlorine into the water system - it was very hard to turn. If you tried to force it, you could force it on down there, and I'm sure that's a good way to break an ampule on the thing. In two cases, we took the bayonet fitting loose again and put it back on there, and in both cases, then you'd start to squeeze the chlorine out of the ampule into the system, and it would turn easier.

CERNAN We got the chlorination done. We didn't miss any injections of chlorine, and we didn't miss any of the buffer samples. I guess we got the job done; it was just a little bit messy. The

CERNAN (CONT'D) chlorine was evident because the **CDR** eventually peeled **all** the **outer** skin off his right hand. I'm convinced it **was** due to the chlorine, and had nothing to do with the EVA.

14.0 TRANSEARTH COAST

CERNAN Passive thermal control was what I would call unusual attitude because of the UV/IR requirements. These unusual attitudes did two things. They required us to remaneuver the spacecraft several times and enter and exit PTC several, several times, which, in itself was not a problem, just additional coordination. Coincidentally, most of these particular PTC attitudes were within 30°, certainly 45°, of gimbal lock most of the time. We were looking at the red apple a good portion of the trip home.

Some of those attitudes where you actually were in attitude or PTC in these relatively unusual positions, change the equilibrium heat load on the spacecraft. RCS quad temperatures were all right, but you could see it in helium package temperatures and, most noticeably, you could see it on the change in condensation from the tall hatch to the forward hatch. The tall hatch eventually, for most of the way home, ended up to be very dry. The second day out on the way home, the center hatch got soaking wet to point that we even took a dry rag and wiped off some of the latch components and some of the gearbox components, externally. Not that it did much good, but there was just that much water on there. I think this is all due to the PTC attitudes required for the SIM bay experiments on the way home.

SCHMITT It was cold in the spacecraft, too.

CERNAN Oh, yes, it wits cold in the spacecraft.

SCHMITT Not as cold as the commander thought it was.

CERNAN Cold enough to warm it up, on the commander's orders.

SCHMITT We mentioned we warmed it up on the ground's suggestion of an extra invertor and going to MANUAL on the temp gain. I think we discussed that.

CERNAN Ron, all your REFSMMAT changes, your platform torquings, all those went very well, I thought.

EVANS They were great, went really well.

CERNAN All the way back home, it was just changing attitudes, changing attitudes, changing attitudes, with the exception of the EVA day, which we'll cover here shortly.

EVANS CSM EVA - On EVA prep, we really didn't have any problem. We didn't know of any at that point. The EVA prep went right down the line, essentially. It was well laid out within the experiments checklist. We checked things off as we went, and stayed pretty much on the timeline. We started about a half hour early, and finished a half hour early.

CERNAN We were a half hour early throughout the whole thing, and we lost that half hour in opening the hatch. We turned out to be exactly on time. Where we lost that half hour was on a comm carrier change.

Post-EVA - One thing that helped us immensely on what ended up to be, I think, a very fine entry stowage was that we backed off after EVA and took a good long look at the long-range stowage as well as the post-EVA stowage. We really started housecleaning, cleaning up the cabin, and effectively stowing some of the articles that were not going to be used any further in the mission for entry at that time. Our entry stowage really started with the EVA timeframe period, and I think that really helped us out in the long run.

The only change to the prechecklist and postchecklist was the order in which we doffed and donned suits. It was very evident there were certain convenient ways, because of the way the suits were stowed and the way that people fit into the checklist, that when we donned the suits. The commander was first, then the LMP, and the CMP donned last. It worked out very fine. The CMP had less work to do in his suit, which also aided him in the long run.

CERNAN (CONT'D) In doffing, the LMP was first, then the CDR and then, the *CMP.* That wasn't exactly the way it was called for, but that's the way it worked out.

We stowed our suits in the L-shaped bag prior to putting the center couch back in. This was another good decision, I believe, in helping us get the suits stowed back in that L-shaped bag.

EVANS Cabin depress - No problems. Normal depress. Hatch opening. Even though the cabin was completely depressed, we were reading zero pressure. As soon as I opened the hatch, there was enough residual pressure, or something, inside the spacecraft that it actually tended to pull the hatch out of my hand.

CERNAN Because your suit is bleeding into the cabin all the time, so you never truly get zero.

EVANS That's right, you never truly get zero. The dump valve was still open, and if I had not been hanging onto the hatch, it would have blown it all the way open.

CERNAN That's not unexpected because it's exactly what we had on the lunar surface. We completely dumped the LM. I'd still have to break that hatch loose and hold it open about 6 or 8 inches until things just vented. Then, I could let go of the hatch and open it all the way. If I didn't it would slam back,

CERNAN (CONT'D) closed. It was basically the same thing. You have to open that door and really let things get down to zero.

EVANS When I opened the hatch, all of the little ice crystals started flowing out. A pen went floating by, and something else went floating by - wasn't quite sure what it was. There's all kinds of little particles and pieces that start coming out through the hatch.

CERNAN I looked specifically for the scissors. I didn't see any scissors go out that hatch. I hate to say it. Ron, I'd like to say they went out the hatch, but I sure didn't see them go.

SCHMITT Sure you didn't see them go?

EVANS I caught the one thing that started to go by me, and I put it in your pocket. Once all particles and junk were out of the way we pushed the hatch open. We disconnected the counter-balance with the tool E. So, that we locked the hatch in the open position, so I just shoved it open, it went beyond the center position and locked in the open position with no problem.

Egress - I had a tendency to float up against the MDC. I had to cautiously duck to get my face as close as I could to the bottom of the hatch in order to get the OPS past the MDC and get on out. TV and DAC installation worked fine. I could hang on with the right hand on the hatch, the great big D-handle on

EVANS (CONT'D) the hatch, with the TV pole in my left hand. Worked out real fine. Just stick it in there and line it up; make sure it was locked in, then climbed on up the pole to turn the TV on. I turned the back on. You couldn't see the light on the thing, but you could feel the camera running once you turned it on. You could touch it and you could feel it vibrate a little bit.

The lunar sounder cassette retrieval should be on the air-to-ground tapes. Most of it was no problem.

The pan camera cassettes were next. No problem on the pan camera cassettes. It's obviously a bigger mass, and it's quite apparent when you try to move that big mass around. It is heavier and it weighs more than the other things. It's easy to move, but it is it takes a little effort to get it started. You know that if you ever get it started in one direction and it's going to keep on going and you have to stop it. I just tried to keep it under control. Mapping camera cassette had the same problem I had in the SIM bay c^2f^2. That was getting the thermal cover off. It stuck underneath the mapping camera laser altimeter door. I gave it a big jerk and it came off.

SIM bay inspection - That's all covered in the air-to-ground tapes. TV/DAC removal again was real simple. You just had to squeeze the lever and TV came out. It was easy to hang on

to with one hand and maneuver the TV around and point it toward the Moon. I didn't have to worry about shining it into the Sun. I tried to again hang on with one hand and point the TV around toward the Earth. The Earth was maybe 15° away from the Sun. I tried to be a little more accurate. When I did that I really lost control of my body position. I was trying to maneuver the camera. You need both hands to maintain your body control.

Comm during EVA was loud and clear for me throughout the EVA. There was a lot of background noise; I'm sure it was coming over the VOX circuit.

CERNAN It didn't appear to me that anyone on the ground had trouble reading you.

SCHMITT One thing we did because it was bothering us I turned the VOX sensitivity down about two notches. That really improved the comm performance.

EVANS I don't know if it made any difference or not, but I got the impression that it did help.

CERNAN Comm into the cabin was excellent. I never had any trouble understanding with that hissing in the background.

EVANS Ingress - It seemed to me it was easier than egress. For some reason, hatch closing was harder than I'd anticipated. Maybe this is the same reason in that I must have been exhausting into the cabin all the time. That hatch would come closed to within about an inch of closing on the outer edge. Then it took an effort to pull the hatch closed so you could activate the latching handle so that you could get the latches over center. Of course, once you got the latches over center, it was real easy, a couple more cranks on the hatch for closing.

Repress was normal.

SCHMITT All I did was work in the hatch area. I want to emphasize what everybody's always said that you do your best work when everything's going easy. Move yourself in small increments to where you want to go. You can turn and dip and raise yourself out. I think it's also useful for any hatch or port operation to have somebody available to push you out on your tether towards where you want to go. It just eases the operation. With the struts and everything available there, there was never any feeling there that I could not have a way to control my body position. Sometimes it took a few seconds to get it where I wanted. The one thing, invariably, everytime I went back inside I had the 90° disorientation for a few seconds

until I got the perspective of the cabin again. I'd say okay, that's right. Then I would go back outside and come back in, and once again it seemed that cabin had rotated 90° to my perspective. It's just something that's no problem, it's just a change of perspective. For some reason, I experienced it several times. I guess the biggest problem working in that angle for me, attitude, was I had the Sun full face.

EVANS You had the Sun in your eyes most of the time.

SCHMITT It made it hard to look in detail to see what you're doing. You were clear image; you were there. I could see every major operation, but I could not see specific details.

EVANS I had no awareness whatsoever that I had an umbilical on my back. I never got the feeling that the umbilical was restricting my movements. I didn't even know that it was there, Did you observe at any time, did the umbilical ever get tangled around.

SCHMITT No, the umbilical was easy to tend. There may have been one. I had a vague impression that I asked you to hold up, or maybe I did not say anything, I just moved you away from a handhold or something. The umbilical didn't seem to slink around. You seemed to have everything you needed on it.

EVANS I did not even know it was there. Being tied to the umbilical does not restrict your movement or give you a feeling that it is restricting your movement at all.

Transearth - I did not see a light flash.

SCHMITT That evening I did see them again falling asleep.

EVANS I did, too.

SCHMITT So then, it was just that period during the actual experiment for some reason they were not visible.

EVANS We never really utilized the waste stowage vent to get rid of any odors out of that waste stowage compartment. It was always a crime if you were in that area, if you got real close to it.

SCHMITT The cabin generally turned over the atmosphere in pretty good style. It got saturated sometimes with gas and it took a few minutes to clear. *The* cabin did a good job.

CERNAN Flight Plan updates were super. The Flight Plan was excellent. Changes were held to a minimum, and we really did not change any part of the entire flight except a few dates, times, and attitudes.

CERNAN (CONT'D) Entry preparations began after EVA and continued all through the next day. We had very little final stowage to do on the final entry morning, just those things we had to leave unstowed until we got out of our sleep restraints. Basically, we just had to tie the big bags dawn. Final entry preparations went by the checklist. If anything, we stayed about 5 minutes ahead throughout the entire checklist, including separation and activation of the command module RCS and .05g, which came on time. Communications I thought were very good through this time. I understand the ground heard everything we said right through blackout. As soon as we came out, they still had ARIA, and they could still read us. We could have read them, but they never transmitted anything.

15.0 ENTRY

EVANS Prior to midcourse 7, we did a null bias check and also an EMS Delta-V test. The Delta-V test had been going at about minus 22.2 or 22.1 at the end of the 10 seconds. Then prior to midcourse 7, we ended up with a minus 27. We'll have to check the air-to-ground tapes, but it still was within limits. We'll check the air-to-ground on the actual values of this, but it failed the null bias check by a considerable amount. Since it did that, I went through an extra EMS entry check. It passed that EMS entry check. I can't say for sure whether the .05g light was on during test 1 or not. It was on during the second EMS check. As a result of that, it was determined by the ground that the accelerometer in the EMS was probably putting out a couple of extra pulses. It was decided to change the entry checklist so that we would not put the EMS to normal until .05g time. This is what we did. The .05g light came on, and the EMS functioned correctly throughout the entry. Entry parameters are on the air-to-ground tapes and also on the frames.

The RCS sounds were a little bit louder than we'd been practicing with in the simulator, I thought. I've also mentioned the drifting and the cross coupling and minimum-impulse SPS.

CERNAN Is it louder or more of a bang?

SCHMITT It was less than the LM and more than the service module. That's a good way to put it.

CERNAN Banging on a solid can.

EVANS Communications blackout - You'd never know it from inside the spacecraft.

Ionization - Ionization is bright. It was very bright, very bright.

SCHMITT There seemed to be an early glow. Now, whether that was ionization or the initiation of the fireball, I don't know,

CERNAN They're one and the same.

EVANS They're one and the same, I think.

SCHMITT Yes, but with the true fireball, it would seem to me that that would be something that you really couldn't look at. I couldn't look at it; it was too bright. I couldn't stand it.

EVANS You couldn't look out the rendezvous windows at the fireball because it was too bright. I felt like I should have put on my sunglasses in order to be able to see. That intensity only lasted for about 10 seconds, maybe a little longer.

CERNAN It was longer than that;.

EVANS It's hard to remember for sure.

Peak-g - The one thing I can recall about peak-g is that I definitely could not see the peak-g value on the EMS because I couldn't see where the pointer was on the EMS. I determined peak-g by looking at the g-meter. I could read the g-meter, and it was something just less than 7. You're pretty well pinned to the back of the seat at peak-g. You definitely have wrist action with no problem, but trying to raise your arm took a lot of effort. I don't think you'd ever get your arm up if you didn't already have it up at 6g.

Guidance Termination - No comment.

CERNAN Let me talk about guidance for a minute. The CMP was in the left seat, monitoring the EMS, g's, and what have you. I was in the center seat, monitoring CMC and passing bank angle information so we could come to a logical conclusion about giving the spacecraft over to the CMC for guidance. I had the impression after peak-g that the two of us were very close to convincing ourselves that the CMC was not going to roll the spacecraft.

EVANS That's right.

CERNAN It seemed like it took a long time for CMC guidance to roll the spacecraft back out of peak-g. I had the impression that you were just waiting for me to say, "Let's take it back," and we would have taken it. It seemed that it was longer than the simulator. It was a long time before the CMC made its first initial roll command, almost too long. In another couple of seconds, I think we might have taken it over.

EVANS We might have taken it over. I think the reason that we felt that way was because most of the runs that we ran in the simulator were nominal runs where you get about 6.1g. If you get 6.1 or 6.2g, you do reverse the bank angle to a one-eighth roll quicker than you do if you have a higher peak-g. We were pretty close to the 7. I don't know if you ever saw 7 on the DSKY or not.

CERNAN No, I never saw 7g, to my knowledge.

EVANS I never did see 7.

CERNAN I saw 6.64 or 6.65, something like that, but that's about as much as I ever saw. It just occurred to us that the CMC was never going to get around to rolling 180'. Once it did roll 180° to the best of my recollection, it never rolled except from left to right. It never rolled across the top again. It went from 90 or 100 one way, and 70, 80, 90, or 100 the other

CERNAN (CONT'D) way but never made the complete turn again. It just rolled left and rolled right, rolled left and rolled right.

EVANS Visual sightings and oscillations - The one thing I forgot to look for was that in the simulator from about 90 000 on down to 50 000, it starts pitching. I don't remember if we ever got that pitch rate going or not. I think most of my comments should be on the air-to-ground tapes throughout the entry. Those would be more appropriate than something I might recall at this point in time.

SCHMITT I think we all had about the same impressions. My standard comments for launch and entry are that there are certain periods of time that lasted for several minutes where I don't think you would be too extensively doing malfunction analysis and problem solving, particularly during peak-g. I think you're mainly concentrating on the g-load, and it would be hard to move your arm anyway to take care of any problem with the switches or otherwise. I'm not saying you shouldn't simulate it. You learn a lot of systems and that sort of thing, but I don't think you can anticipate doing work during that period of time.

CERNAN I thought the droque deployment was violent. I thought the spacecraft oscillations were quite violent. I'm not saying

CERNAN (CONT'D) that there was that much difference than I personally witnessed in the past. I just forgot to expect the violence of the oscillations on the drogue.

SCHMITT I was watching the drogues, and they were moving just as hard as the spacecraft. I think that the drogue movement was being transferred to the spacecraft.

CERNAN We had all drogue deploy, all main deploy, and once we had the mains, apparently we had two good parachutes.

SCHMITT I watched the full main deployment, and I could see all three reefed parachutes after deployment. They stayed reefed probably about the amount of time you'd expect them to. Then you could see the reefing lines start to go, and the two parachutes that were on my right filled fairly quickly and seemed to push the left parachute away and out of the main slipstream. It filled much more slowly. It was clear to me, and it should be in the photographs, that the reefing lines were free. The parachute was not filling. Then gradually, it filled completely. I would say it was 15 or 20 seconds before that other parachute filled completely. It was sluggish. It just got pushed out of the way and couldn't get the full flow of the air to fill it.

CERNAN And I think that some of the people on the recovery team said that they saw the two parachutes plus the streamer.

SCHMITT I wouldn't call it a streamer. It was just unreefed. It was just still reefed.

EVANS I'd like to make a comment about the dynamic visual cues of rotation. Throughout the entry, I didn't really feel that I was rolling. I didn't get a feeling of dynamic roll other than the fact that I was watching the needles. There were no centrifugal forces involved in that operation until we were on the main parachutes. When we were on the main parachutes, I felt like I was lying on my back on a revolving table.

SCHMITT I suspect that might be because of the higher g-loads when all these other things were happening. I don't know how much you were looking at the horizon as you rolled, but that's all I had to look at.

EVANS I could see the roll. I had the visual sensations of it, but I didn't have the dynamic feeling of roll until we were on the main parachutes. While we were on the main parachutes, the roll was not continuous in one direction. It was rolling in one direction at 15° to 20° per second, and for some reason, it would reverse and go back the other way. The rolling sensation on the parachutes was kind of a wind and unwind type of a roll.

SCHMITT The DAC operation was normal. We took a little bit of extra footage early of the horizon which I hope turns out. I don't

SCHMITT (CONT'D) understand why you turn the DAC off after you're on the mains. There's no reason to. We ended up with some unexposed footage.

CERNAN Oh, you did? I thought you let it run out.

SCHMITT No, the checklist said, "Stop DAC," and I stopped DAC and it was a little while later that I wondered why I stopped the DAC.

CERNAN I'm sorry. I thought you let it run out.

SCHMITT I don't know if we would have gained anything by it except some more pictures, but there was no reason to turn it off.

EVANS Communications - From 90 000 feet until about main parachute deployment, I had a time trying to hear Jack. There was a lot of background noise.

SCHMITT That's right; I remember that.

EVANS It just gets noisy in the spacecraft from about 90 000 feet on down. Once you get the altimeter off the peg, I had a time hearing you call out.

SCHMITT I was shouting, too. I realized you were having trouble hearing. There was noise. It must have been air noise coming through the hull.

EVANS It was something.

CERNAN You were on VOX that whole time. You could have been keying, and that noise could have been coming through your VOX. I'm not sure. That takes care of entry, which was a good one.

SCHMITT Let's mention ECS. I never was uncomfortably warm in the cabin at all, even through hatch opening,

CERNAN We cooled the spacecraft effectively. Just normal powerup of the ECS systems cooled the spacecraft down prior to entry, and it was comfortable. Even after we landed when it normally does warm up because of humidity et cetera, it was still very comfortable. I never thought it got hot or extremely humid throughout the whole recovery operation. The altimeter read about 100 feet when we hit. We'd been warned that we might hit with 17 feet on the altimeter. We made callouts all the way down on crew condition, altitudes, and the DSKY read-out in terms of position. They had a visual on us all the way down. We were right next to the ship, apparently right at the zero aim point.

16.0 LANDING AND RECOVERY

CERNAN We hit with a pretty good thud. As soon as we recovered from the thud, the LMP went for the main parachute release breakers and I hit the switch. The parachutes, apparently from the lack of a great deal of wind, just rose petaled in an almost 120° position around the spacecraft. We had no tendency of ever going stable II, partly because of the seas and the wind and also because we released the parachutes in a hurry. We proceeded to go through the postlanding checklist. In addition to what we said about the temperature and humidity, I think the postlanding vents certainly did help. We had that running. We had communications with Recovery all the way down on the parachutes. We monitored the recovery all the way through by communicating with the recovery chopper. Spacecraft status was excellent. We followed through the checklist; and, although it was not needed, the checklist calls out to inflate the bags after you've been on the surface 10 minutes. We inflated the bags for 7 minutes after we'd been on the surface for 10. It is a good idea in spite of the fact that they were not needed because it does give you that added protection of staying in in stable I in case you might end up going over. There was no seasickness.

SCHMITT We did not put the postlanding vent ducts up although they were available. There was plenty of air moving in the cabin from the normal ventilation. You could feel it. You could feel it move. I don't know about you fellows, but I had plenty of air.

EVANS I had plenty of air coming across on the left couch, too.

CERNAN The CDR climbed out of the center couch, went down to the LEB and got the cosmic ray prepared and available. We stood by for hatch opening. When the hatch opened, we received the bag with the lifevest, the cosmic ray protector box, and the temperature gage. We put the temperature gage on, the cosmic ray was stowed in the waterproof package, and we put on our vests. When we were ready to open the hatch for the final time, we powered down the spacecraft via the checklist and panel 250.

SCHMITT I would call the touchdown a very sharp crack rather than a thud. It is an obvious sensation. It's not one that seriously jarred you or hurt you in any way. It was a sharp and abrupt stop. I think it might have taken me 2 or 3 seconds to start making a motion towards the breakers. There was enough jar to say, "Okay, I better recover from it," and then I reached for the breakers. The windows fogged up inside almost immediately and there was also material on them on the outside. It looked like something other than moisture on the outside. It was sort of a brownish yellow. I had no motion sickness at all, but

SCHMITT (CONT'D) I didn't really care whether I got up out of the couch or not for a while. I didn't have the desire and that's about all I can say as far as any change of feeling from zero-g to one-g. I noticed that my neck muscles seemed to be really working to hold up my head up. It was much more than normal and this persisted for about 24 hours. It gradually went away until about 24 hours later I felt perfectly normal raising my head.

EVANS I guess I didn't even notice the transition from zero-g to one-g. I didn't pay that much attention to it.

CERNAN I didn't really notice any difference either. I particularly got up on the LEB to see if I would but I didn't.

SCHMITT On the egress, my lifevest did not inflate automatically. That might be worth looking into, because apparently they were a new set sent out specifically because the first set sent out had not gone through inspection. These presumably had and they still did not inflate. Only one out of the three inflated all right.

EVANS Another point I want to make is that if we're going to put that temperature gage in I would recommend that you send in a roll of tape, a bungee, or something so you can strap it to the strut. We just happened to have a piece of tape in the LEB so we could tape it to the strut.

SCHMITT Crew pickup for the LMP was exactly as I'd been told it would be. We practiced on Apollo 15.

CERNAN I don't think there is any other comment on crew pickup other than to say that it was done in an outstanding manner.

EVANS I concur. It was good.

17.0 TRAINING

EVANS CMS - The crew station was always in good shape. Some of the interior storage was boxes, but the items of storage equipment that needed to be used were always there. Jerry Stoner and his crew kept it in excellent orbital storage most of the time. If we wanted it restowed for a SIM, for lift-off, or anything, all we had to do was let him know and they were in there all hours of the day and night to get everything squared away. Fidelity of the CMS - I've mentioned the differences in the actual vehicle and the CMS in the various other sections of the report. They are minor. Availability - The CMS was always available any time I wanted it - more than I could use it in some cases. The people involved in the CMS training - knowing full well that Apollo 17 was their last shot - were outstanding in their desire to continue training and to put out their best efforts in insuring that I was trained and ready to go. Visual systems. I didn't seem to have any problems with that. The biggest problem was in the star ball. Every once in a while it would get fouled up. That and the sextant drive were a little bit jerky but it worked great. Software - F computer was going all the time. If it ever conked out, they fixed it fast.

SCHMITT I echo all of Ron's good words about the quality of the training and the dedication of the troops down there. From the systems point of view, I think the fidelity of the systems was all that was required and was generally very high. Only those differences that were spacecraft peculiar were the ones that were not simulated. Where there were other comments to be made, they have been made in conjunction with systems work. Availability was fine as far as I'm concerned. The visual systems were good. The only ones that really concerned me were the entry visuals and they were certainly adequate, although they do not give full representation in drogue and main deployment.

LMS - we never really stowed the LMS. The gear necessary for general training was perfectly adequate. All of our crew-station-type training was done in the mockup of the LMS. We've also mentioned the fidelity of the training and wherever there was differences, the L&A and the AOT were excellent representations, based on a little bit of comparison that I did. The AGS software in flight was just like the AGS software in the simulator with one well-known exception. You get your displays faster in the simulator than you do in the flight but this was never a problem. My work with the PNGS is limited and confirms what the CDR has already said, that the PGNS in the simulator and PGNS in flight are essentially the same.

SCHMITT (CONT'D) The LRV navigation simulator - The main usefulness I received from this simulator was working over the traverses and understanding and knowing what we were supposed to do. The comparison of driving on the lunar surface with that of the simulator was very poor. I think the problem is that the simulator has to give you a much higher point of view. The simulator is 20, 30, maybe 40 feet higher above the surface. When you're down at 4 or 5 feet, as you are in the LRV, it's a different world. It makes a big difference in what you recognize. The other side of that coin is that once we started moving on EVA-2 and EVA-3, there was never any difficulty on the lunar surface of recognizing the larger features that we had seen on the LRV simulator. So it worked out very well.

CMS/LMS simulations - In general, the integrated work we did always went very well.

EVANS I think it did. We lost 1/2 day on an integrated sim.

SCHMITT I think the few places where we ran a little bit behind in flight were those portions we never really simulated, such as suiting operations and the tunnel operations. They went smoothly, too., I think not simulating them in detail was a good decision, and I don't think it affected our operations.

EVANS I don't think so, either.

SNS - I don't know how you can ever overcome this, because in the SNS you are training the crew and you're also trying to train the MOCR. There isn't that much for the CMP to do to keep busy all the time from a training standpoint. I don't know if that's necessarily bad or not.

SCHMITT We had a few excellent SNS, from the standpoint of fairly continuous activity. In general, Ron's comments are valid for Apollo 17. If my memory serves me correctly, Apollo 15 SNS were much more active. And I don't know why there might have been that difference.

EVANS On Apollo 14 backup crew, I was more in a learning stage at that point than I was on Apollo 17. In Apollo 17, it was more of a review stage for training than anything else.

SCHMITT I think that's a natural point.

EVANS DCPS - We tried to get it once every 2 weeks, which we did in the first part of the training cycle. The last 3 months we were lucky to get into the DCPS once a month. I feel it's a necessary part of the training and should definitely be continued. The CMPS was shut down after Apollo 16, so all of my rendezvous rescue procedures and training was accomplished

EVANS (CONT'D) prior to Apollo 16, with a final review of the rescue book about a month prior to the Apollo 17 launch.

SCHMITT I'd like to make a general remark about CMPS and LMPS type simulators for future programs. If you ever have a program where you're bringing in a new group of people to fly your spacecraft, this type of facility is extremely valuable. It gives a new man a chance to train without the constraints of simulator ties. He doesn't have the pressure of other crewmen looking over his shoulder and evaluating his performance. He can figure out how to do things, what a simulator really is, and what many of the more standard procedures are. I think it's a very valuable type of simulation. When you're dealing with a large pool of experienced crewmen, then that type of simulator is not necessary. This type of simulator develops habit patterns which are necessary in order to move on to the total mission simulators. Let me go back to SNSs. I had a feeling - and again I'm comparing with 15 - the total readiness of the combined MOCR and crew team came up more slowly than it did on 15, sometimes more slowly than I expected it to. But, at the end, I had the feeling that we were every bit as ready as a team as we were on 15. There was a lot of Skylab work for a lot of people there and I think that may have affected the rate in which we came up.

EVANS Command module egress training - The mockups over in building 5 were utilized from an EVA standpoint for the CMP. The probe and drogue mockup was utilized several times. The last was a review and a final check. This is an absolute necessity for the drogue operations and also for the command module EVA operations. You need to utilize the mission simulator once or twice to tie in the systems procedures with the mockup procedures.

SCHMITT The lunar module pilot's egress training was largely accomplished on Apollo 15. We did procedures reviews or mockup reviews and I did not get into the water tank for Apollo 17. The launch pad final walkdown came at a good time. The normal training we did in the hy-pergolic building was standard and excellent. I think it was good familiarization.

EVANS It was good familiarization and also a must.

SCHMITT It's a confidence builder and I think you ought to do it. The altitude chamber work tends to give you a little bit of egress training just because you have to deal with a real vacuum. I think that also is something you just pick up but that adds to your total readiness as far as egress is concerned.

EVANS The water tank is where I received most of *my* EVA training. The water tank is a pretty good representation of zero-g.

EVANS (CONT'D) It was a lot better for me than the zero-g airplane. I became sick in the zero-g airplane every time except one. I never became sick in flight and never felt like I was going to be sick in flight. Every time I got on the zero-g airplane I always wanted to get as much done as possible before I started throwing up. I don't have too much confidence in the zero-g airplane even though I flew in it four or five times.

CERNAN I'll make some general comments about the CMS training. The CMS, from a hardware point of view, supported our mission in an excellent fashion. I think the crew at the Cape made themselves particularly available and were a vital part of the training. They did an outstanding job. The CMS is always limited in a visual and a dynamic system because it is a fixed-base simulator. I think within the capabilities that it has to reproduce the visual, we received a good preview of what this flight was going to be about. It was mentioned earlier that for launch and reentries there are certain periods of time that you can not do in the real world that you can in a simulator because of the dynamic g-forces. It was also mentioned that this method of training in solving systems problems during those phases is still an excellent way in which to train as long as you realize that there are certain phases in the dynamic portions of the mission in which you will not be able to exercise the freedom that you can in the simulator. The LMS

CERNAN (CONT'D) from a hardware as well as an individual instructor support point of view supported our mission, in outstanding fashion. The entire system was excellent. The L&A, from a gross recognition point of view, was a duplicate of Taurus-Littrow. When we pitched over, it was almost like being in the L&A, except you very obviously got the realistic three-dimensional feeling. All of the software practices we used in the simulator were used in the spacecraft. The duplication of the spacecraft's software on the ground in the simulators was outstanding because I never had any problems or overloads. Everything performed just as advertised. I want to mention something about the LRV navigation simulator. It's a very good area familiarization simulator. I anticipated it would be a real great navigation driving simulator, but it's really just an area familiarization simulator in terms of driving from station to station and completing your EVA traverses. I think its major shortcoming is you never get the feeling of size or distance on this simulator, because on the Moon you have to at least double or quadruple your estimate of size and distance. You do not get that on the lunar Rover navigation simulator. You do not get involved in what it takes to drive the lunar Rover on the simulator and I don't just mean the 1/2-g effect. I mean the effect that in the real world when you drive the Rover you are continually avoiding rocks, holes, and craters. Some

CERNAN (CONT'D) you can see and some you can't quite see. It's a continuous requirement to watch where you're going. The duty cycle of the controller is almost 100 percent. You do not have this requirement on the lunar Rover navigation simulator, and it's a little unrealistic from that point of view. We didn't spend that much time on the LRNS and I'm thankful we didn't. I thought it would be more valuable. The simulations we had with Houston and the integrated sims at the Cape went very well. We had very few hardware problems. The LMS in the last couple weeks had hardware problems now and then, but the people were able to recover and we only lost 1/2 day, and I think we made that up.

WARD The backup crew essentially lost a day.

CERNAN The DCPS in Houston was used extensively until 3 or 4 months before the flight. I'm very glad I did that because it was not just abort training, but it was abort and booster familiarization work. I felt very comfortable in flying the aborts as well as the manual takeovers on the booster. The rest of that training was done at the Cape in the CMS and I never felt anything but at home and quite knowledgeable about that part of the training.

CERNAN (CONT'D) CM/LM egress - The altitude chambers speak for themselves. We did the launch pad work. We did water tank and not Gulf egress work and I heartily recommend that.

Systems briefings went hand in hand with our simulator briefings from the simulator people. We did a lot of those very early and then just kept up the speed as we felt we needed them throughout the last 4 or 5 months with the other training.

SCHMITT I spent a lot of time, the first 6 or 8 months, with the flight control division people going over the various systems that I was concerned with. I found this very valuable, not only in learning the systems but in learning how they were thinking about these systems. Once we were at the Cape, most of that kind of training was done directly with the simulator people, who did an excellent job. I was in fairly continuous phone contact with the Flight Control Division people to whom I talked earlier. This combination kept my system's knowledge pretty well up to date. I think it was an excellent way to approach the problem.

CERNAN Simulator training plans - Eight to ten months *ago,* I sat down with the training coordinator and the senior simulator people at the Cape and asked the people there to go into the back simulator training history of the entire crew, because each crewman had a little different background. We found out

CERNAN (CONT'D) where we all stood in terms of our simulator background looking forward to our future total simulator requirements. We tried to emphasize scheduling to fill in our weak spots. We reviewed this periodically - about every month - just to see how our training was going. This type of review with the simulator people did two things. I made them work out a particular schedule which we did our best to live up to, and it gave them a schedule that they could work on, plan on, and get ready to brief on. It made sure that we covered all areas which we could have skipped if we just randomly went out and told them what we wanted to do. In addition, I asked them to make sure the backup crew did not go off in one direction while we went off in another. The backup crew ran within the same time frame, the same type of training that we ran. In addition, they verified all our flight procedures and checklists. They could uncover possible errors or shortcomings in the procedures, due to their experience, that we might not. I think that all paid off. In the end we had all the important squares filled. The initial simulator requirement time was now an academic number because we knew exactly what we had done and where our strong points were. We reevaluated our entire simulator background and found out we were in pretty good shape. We probably spent more time in science training, both in the mechanics of ALSEP development and SIM bay

CERNAN (CONT'D) operation as well as from orbital geology to geogeology work, than any other crew in the past. And at the time it seemed like we were expending almost too much time in this area. But, in retrospect, I've got to say, it was time very well spent although it was time that had to come at the expense of something else. But I think those things were reasonable in terms of our previous training and background and not compromise the entire training and readiness for the flight.

SCHMITT Let me add a comment to science training. We made a very special effort, and many people in the Science and Applications Directorate went out of their way, particularly people associated with contractor support, to see that we had extensive exposure to the lunar sample. I think that in itself also paid off handsomely in recognition of rock types on the lunar surface. Those people are to be complimented doing what - in a time of tight budgets - is a difficult thing to do and let us see the lunar rocks. They also supported very frequently with 2- or 3-hour discussions on various lunar problems, which also was above and beyond the call of duty.

EVANS Orbital geology - From my standpoint, three people were indispensable in this respect. Dick Laidley, Jeff Warner, and Farouk El Baz, each in their own little areas. Dick Laidley was indispensable in that he had been the pilot and the CMP's

EVANS (CONT'D) geologist so to speak for Apollo 16 and for the field trips involved - getting ready, knowing where to go, how to follow flight plans, what to expect, what photos to take, and this type of thing - he's indispensable from that standpoint. Jeff Warner took over and organized the rest of the scientific briefings for the CMP, got these squared away, and participated in the field trips from the low-altitude standpoint and also with the site specialists. Farouk came into his own along towards the end of the training cycle when we were involved primarily in the crew familiarization and training of the lunar geology itself. I think in each case we had the right amount of field trips. We just about exhausted all of the field trips that were available, since we got an early start on them. Even though you like to get a refresher field trip along toward the end of the training cycle, there just doesn't seem to be time to get it in. The lunar geology should also begin close to the end of the training cycle and continue on up to launch, which it did. You really don't need to make a recommendation any more, but El Baz should have been on the primary contact list.

SCHMITT Well, I think that would go for any activity, in Earth orbit or anywhere.

EVANS It's hard to work through a window. It can be accomplished, but it's a lot easier to be side by side. One more for

EVANS (CONT'D) identification training. We had good landmark maps. We only had four or five of them and so not a whole lot of time was involved in that because they were pictured quite well.

SIM bay training - In the early part of the training cycle, I was essentially following the manufacturing and the design really of the the lunar sounder, so I was somewhat involved in the initial part of that. And then you get down to the final stages of it and work through the ASPO people and the FOD people as well as the people on the CMS who keep you up to date on the nitty gritty and the systems diagrams and that part of the training. And it was sufficient and adequate.

SCHMITT The 1/6g aircraft - I always felt that there's an important but limited area for the 1/6g procedures. I think if nothing else it paid off in evaluating the LRV sampler and convinced us that it was a feasible way to sample. I think for general familiarity with part tasks that could be accomplished in 20 seconds or so that the 1/6g aircraft was extremely valuable and those people did an outstanding job of supporting us. I mean Jack Slight and the Air Force and NASA in general. I also think the K-bird is a good vestibular trainer in spite of the fact it's very uncomfortable. I think it's probably worth doing a couple of times - for myself, anyway, to keep my vestibular system in some kind of condition.

SCHMITT (CONT'D) One-g walkthroughs - Well, mainly that's familiarity, and that's exactly what it did and it was extremely useful. Field trips - If we checked the number of trips, we probably had a little less than 15 or 16 did, but nevertheless they were well organized. They were mostly to brand new areas, so the people should be complimented on coming up with trips that had never been done before. That was mainly in order to keep the LMP from seeing a lot of familiar terrain. The support we received, the cooperation of the U.S. Geological Survey and the Science Mapping Directorate, was outstanding. I think all problems that existed several years ago and continued to exist to a limited extent were just about gone if not completely gone. The groups are working together extremely well and I understand continue to work together through the mission in various capacities in supporting our operations on the surface. We appreciated it very much.

The LRV trainer - The LMP did not have too much to do with that. He went through the normal familiarization to drive it and knew the systems remarkably well. I think the one unit we got the most out of was the Grover, which was a U.S.G.S.-built machine that we used on field trips. It had a lot to do with getting us used to the problems and advantages of using a four-wheel drive vehicle for geological explorations. In particular, I know the CDR would comment and he may yet that the Grover was

SCHMITT (CONT'D) good for emphasizing the amount of time you have to spend in driving versus what you would normally expect to see on the LRV simulator.

The CSD chamber work was extremely valuable. The two runs on the PLSS and going through the EVA prep and post operations in the chamber and using our flight PLSSs, and backup PLSSs was some of the most valuable EVA training we received in my opinion.

EVANS I think I can just pretty much second that although my training was strictly on the umbilical, the O_2 umbilical and OPS. In both cases, the first one was strictly a familiarization and confidence-type builder, knowing that you can survive and move in a vacuum with all of this equipment. The second run was more a refamiliarization with the equipment and also, as far as I'm concerned, a necessity.

SCHMITT The two CSD runs were probably all you needed. We did one early and one late, and I think that was excellent scheduling. The people in the chamber should be complimented for the quality of the training. The schedule is to be complimented for having it in there because it really topped off the EVA prep and post training that we received.

CERNAN And the late one really meant something in terms of us remembering how much pressure there was to put water connectors on. Also, it gave us a closed loop matrix on handling all our EMU gear. As it turned out, we changed out the commander's PLSS. The Grover, I think, was very useful for extending our geology training and putting us in the right environment in terms of distance to cover and getting on and off and what have you. The dynamics of the vehicle were nowhere what the real vehicle is, but it was certainly an advantageous device to have for field training and geology without question.

SCHMITT I mentioned on the Grover, and see if you agree so it's clear on the record, that you commented several times that the driving tasks as termed to workload was comparable in certain kinds of trips.

CERNAN That's a good point, Well worth mentioning again is the fact that even on Earth terrain the guy in the left seat is not going to do much geology. He's going to navigate and he's going to pay attention to the driving task. The Grover brought that home very clearly. I convinced myself that that was going to be the job in a real world.

The one-g trainer that we had down at the Cape I think certainly did more than an adequate job. I felt very much at home in a hardsuit in the Rover in 1/6g because of the work

CERNAN (CONT'D) we had done with the one-g Rover trainer down at the Cape. The reach capability, the control capability with the hand controller, studying the low-gain antennas, the surprising reach on LRV sampling, and taking the sample out of the container bag and reaching over and putting it in the LMP's bag was almost exactly like the one-g trainer.

I personally felt that simulating zero-g contingency EVA training was not worth the time doing. You'll never know, but I still feel that way.

EVANS I concur with you, Gene.

CERNAN Now, you've had some EVA training. Tell us.

EVANS Walking the handrails was a piece of cake. I felt confident in everything that I was doing out there.

CERNAN And it's a case of exercising the procedures in lg. There was no question in my mind but that we could have transferred if we had had to with the training background that we had.

EVANS The next item there is the EVA prep and post training. Jim Ellis had the procedures essentially all squared away from Apollo 16. He made a few modifications to account for the differences in the stowage so all I had to do was to come in,

EVANS (CONT'D) follow through the procedures, and get trained and do it. I think we had the right amount of EVA preps.

CERNAN All of this EVA, both command module and LM prep and post-EVA training - we really walked in the footsteps of the guys who had prepared and exercised the procedures in training and in the real world. And we really altered them very little. We just based our training efforts upon their experience and it paid off. They were good procedures. They worked well in flight, and we did not make many small personal changes to these at all.

SCHMITT I did a couple extra mockup and stowage training exercises and I'm glad I did them. It made me more generally familar with where things were in the command module and I can't say that I really needed it but I felt a lot better once we were up there that I know where A-1 and A-2 were. I didn't have to keep asking Ron quite as often where things were. So if you have the time, it's still useful to the whole crew if you have that familarity.

EVANS I'm also a firm believer in having the CMS fully stowed in whatever orbital operation you're doing, because this space-craft is a lot different when it's fully stowed than when it isn't.

EVANS (CONT'D) Photography and camera training - This flight was essentially review for me. I was familar with the cameras, the photography, and this type of thing.

CERNAN I think that's the case for all three. But we did have a session or two anyway in that area.

Let me say something about the lunar surface experiment training. This goes to the SIM bay, too. When we first got introduced to the new experiment packages, we started out by having briefings by the PIs. It gave us a chance to meet personally and know each other's basic objectives. I think it gave the PIs a feeling that we were interested personally and professionally in carrying out to the greatest extent possible every objective of their experiment. I think, when we launched, every PI was satisfied that everything humanly possible had been written into the Flight Plan to meet the objectives of their experiment. It was a very, very good relationship and I'm very glad we did it.

The LLTV besides being a very enjoyable machine to fly from the pilot's point of view is just one of those things I feel just makes a landing on the Moon that much easier. Puts you in a familar situation. The dynamics of actually being out there on the front of that LLTV are slightly different possibly than the real lunar module, but the roll and pitch and rates

CERNAN (CONT'D) of descent in our actual lunar LM landing were not new and different because of the LLTV experience. I consider it a very valuable piece of time spent in preparation for our lunar landing.

SCHMITT The LMP doesn't have too much activity with respect to lunar landing. We might use manual throtle from the LMP side, and the simulator, with Gene more less in a GCA mode, showed that that was a perfectly adequate way to land the vehicle. I'd also like to compliment the use of the helicopters. The LMP continued to fly those because, in general, that kind of two-handed control has a direct feedback into handling two hands, ACA and PTCA in the LM. Whether you're landing or not, it gives you a two-handed coordination proficiency required to perform those tasks to a fine degree. Particularly, I found that in MI aborts, where we were doing manual attitude control, that the more I flew the helicopter the more finely I could control it for those particular maneuvers.

EVANS In the planning of the training program I thought it was outstanding. I didn't at any time in the training program have to worry about, "What do I have to do next week." It was all taken care of. All I had to do was look at the schedule and say, "Hey, this is it." And press on. I don't believe I ever felt I was doing something unnecessarily. Nor did I feel like

EVANS (CONT'D) I completely missed anything that I should have been doing. You can never get enough training. However, I felt I was confident and ready to go at the right time.

That same logic can be tied into the fact that the trainer requirements were organized many months ago and we took a good look at them. Once they were established and down on paper, you didn't really have to worry about whether you were getting extraneous training or not enough training at that point in time. You knew you were eventually going to get what you needed and it did work out that way. The last week or two you begin to vary from that a little bit, based upon what you want to emphasize, maybe eliminate something you think that you're very familar with. I flew a lot of manual descents and manual launches and manual TLIs the last week or so just to make sure that that would not be the thing that would keep us from going or doing the job. But beyond that, we followed the original planned training program.

SCHMITT The LMP concurs with all of that.

18.0 COMMAND MODULE SYSTEMS OPERATIONS

EVANS The first one is subsystem modes. All we did was utilize the nominal modes of the inertial subsystem. We had no problems, with the exception of one. And I think I should let the CDR talk about that one. The ISS worked real fine. The drift on the platform was phenomenally low. Most of the torquing angles were, within a 12-hour period - .0 blank, blank, or something most of the time.

With the LM aboard, I seldom saw any stars through the telescope, *so* I had to rely on PICAPAR to put a star in the sextant. Once the star was in the sextant, you could assume that it was a correct star because we always had a good platform. If we had needed to do a realinement or a P51, I think the only way we could have done that was to get an initial alinement on a Moon/Earth type of system. The only degrading factor about the optical subsystem was the focus of the sextant, and you just couldn't quite bring the reticle of the sextant into focus. If you cranked the reticle brightness all the way up, you could see the center of the sextant. However, if you cranked it down a little bit, it was hard to see. And even with full bright, it was a little difficult to see, so you never really had it in focus. If you pointed the sextant close to a bright object, for instance, close to the Moon or

EVANS (CONT'D) close to the Earth or close to the Sun, the reticle brightness would be completely blanked out and you'd end up with a black line and two sets of reticles. One would be a heavy black line, and then there was kind of a ghost reticle behind that which wasn't superimposed on the heavy black reticle. I don't know what that was, so I always used the heavy black reticle.

SCHMITT It's not of major importance, but it's interesting that you were continually saying that it was hard to pick groups of stars and to identify groups of stars in the telescope when. you could look out the window, as long as the Sun was on the other side of the spacecraft, and identify constellations with no problem.

EVANS This was particularly true on translunar coast. Even if the Sun was behind you, the reflection off the LM's radar box or RCS quad would interfere with the telescope's field of view. Now on transearth coast, if the optics were looking down-Sun, you could pick up constellations; however not as bright as looking out the window. Around the Moon, even in earthshine, which was very bright, you could pick out constellations. However, they were considerably dimmer than they were in the double umbra on the back side of the Moon. On the back side of the Moon with the double umbra, you could

EVANS (CONT'D) look out and almost see constellations as well as you could by looking out the window, but not quite as well.

SCHMITT I looked once or twice through the optics at the Earth. It appeared to be an excellent Earth-viewing system.

EVANS Yes, it is. A couple of times, I observed the Moon through the sextant. However, the field of view through the sextant was so small that you had to look through the telescope first to see where you were and then look through the sextant because you couldn't recognize the general features at all.

SCHMITT Trim displays and SPS displays - Were they all what you expected?

EVANS Evidently, from where I was sitting in the cockpit, plus 2 and minus 2 on the gimbal drive check always ended up a plus 2.2 and a minus 1.8 from *my* left seat viewing angle.

The trim values were always just a bit higher than what I thought they should be, which didn't bother me much either. I finally got so I would set the SCS gimbal trim position just a bit higher than what I thought they ought to be.

SCHMITT During those checks, each movement of the gimbal was indicated by an increase of amp loads on the buses.

EVANS The other thing that's more noticeable in the vehicle than in the simulator was the feeling of the dynamic motion every time the gimbals move. You also got an indication on the rate display. If you were in the 51 setting, rate display would go up to maybe a tenth of a degree before it would null itself out again. You could definitely see the spacecraft banging back and forth within the dead band.

The CMC SPS TVC - I think the greatest difference in that field and the simulator was in the roll rates involved in the SPS TVC. In all of the burns, the roll rates were almost always up around 0.4° per second within the dead band. In the simulator, it always stayed on the same side of the dead band. But, in the actual vehicle, it would hit one side of the dead band, bounce back, and go back across again at about 0.4' per second and hit the dead band on the other side and then come back. So it was oscillating back and forth across the dead band, whereas we had the simulator pretty much set on a 0.1' per second. I think it always hits one side of the dead band. The pitch and yaw rates during the TVC/SPS burns seemed to be almost steady, very little change. When you had the yaw change during TEI, it was a nice gradual change. The rates were not noticeable at all; just steady as a rock.

EVANS (CONT'D) The only part utilized in the SCS system was attitude control during the TVC checks, and I guess the other time was when NOUN 20 got its glitch. We switched to SCS control, which took care of the rates right off the bat, caged the BMAGs, and maintained attitude quite adequately. I guess entry was the only other time I used SCS minimum impulse on the command module only, after command/service module separation. And, in that case, you always had residual rates, which wanted to yaw the vehicle to the left. You had to continually yaw it to the right, and in pitch when I was trying to pitch down, it would continually decrease the pitch-down rate. It was essentially evolving its own body pitch up. But, minimum impulse, control of the command module only, is quite adequate. It's a little bit different than the simulator in that in the simulator, roll control is the one you can't quite get with one minimum impulse blip back into zero roll. In the vehicle's case, it's yaw. You'd either give one blip, and it would go to the other side. You'd give it a blip back the other way, and it'd never end up with a zero rate in the yaw axis. However, I never did try it with the single ring authority. The only maneuvering I did again is the minimum impulse on the command module in SCS.

Thrust vector - We never did any SCS/SPS burns.

EVANS (CONT'D) Power up/power down. We never did power down. It was powered up all the time. We never did power it down.

Attitude hold worked quite well. Whenever you switched to SCS control and you had all 16 auto RCS selects on, then you had a continual bang, bang, bang, back and forth within the roll dead band. If you put limit cycle on, that kind of knocked it down a little bit. But, of course, the best way to control SCS in roll is to use two-quad authority and not four-quad.

The Delta thrust switch - I would always wait until average g on the computer before bringing the Delta-V thrust A switch. All burns were started on Delta thrust A first. Or, if it was a single-bank burn, it was Delta-V thrust A.

The Delta-V remaining counter and rocker - the EMS Delta-V worked real fine. The difference between the actual spacecraft and the CMS is that in the CMS, you can see them count up and down, but in the command module when you held the button down to maximum increase or decrease, the last three digits remain solid. It really counts up, so you wouldn't have time between each of the counters to see the numbers change. It stayed on whatever number it was on. Actually, it just sat there as an eight, a constant eight all the time because it was whipping through there so fast. The Delta-V

EVANS (CONT'D) test worked all the time. There was always a minus 22.2 or 22.1 on all of the EMS Delta-V tests except the one prior to entry, which ended up as minus 27 or something. That's when the accelerometer was picking up some extraneous counts and counting a little bit more than it should have.

SPS thrust direct ON switch - I never did use it.

Direct ullage button - I never did push the direct ullage button. I don't even know if it worked.

Thrust ON button - I never did push the thrust ON button, so I don't know if it worked, either.

Engine thrust vector alinement - I don't recall any attitude deviations or maximum rate changes because of thrust vector misalinement at the initiation of any of the burns.

SPS chamber pressure indicator - During the LOI burn, the bank A indicator came up to about 87 percent, which was a little lower than anticipated. I was expecting somewhere around 95 or 97, somewhere in there. That's about 10 percent lower than expected. When I turned on bank B, I got the nominal 5 percent increase, and then throughout the LOI burn, the chamber pressure just gradually increased a little bit and finally got up to about 97 percent at the end of the burn.

EVANS (CONT'D) The other anomaly on the chamber pressure indicator was that after the LOI burn, we noticed that we were down around 5 percent, and then later on, sometime in lunar orbit, it ended up back at zero again, and I'm not sure when it went back to zero. On all the rest of the SPS burns, the chamber pressure on bank A would always come up to about 86 to 87 percent and then a 5 psi increase when you put on bank Bravo.

SCHMITT PUGS - The PUGS was essentially nominal in general. Apparently, there were some sensors out, so it was erratic in its sensing of the LOI burn. It tended to hang in the decreased area. I went to decrease and left it in decrease for the LOI burn, and it seemed to try to keep going low. After DOI, we didn't see any real change to it. Then I guess it acted pretty much the same for you on circ. When I came back in, it looked like it had decreased more than when I looked at it last.

EVANS Well, on the plane change burn, the ground called up saying to start it in decrease. So I went to decrease, and I think it didn't have time to stabilize at all because we ended up with a gage with data of 400 decrease.

SCHMITT When we picked it up after that for TEI, we started TEI full decrease and left it there. It was, in fact, low and gradually worked itself up until it was almost balanced about 30 low at the end of the burn.

EVANS That's with the switch in full decrease.

SCHMITT And that corresponded with what we read on the gages. So, I guess you'd say it ended up nominal, but it was a little erratic during the burn, and that may have been the result of those sensors.

EVANS I think I'd better back up there a little bit on the chamber pressure indicator. Evidently, the chamber pressure indicator had a bias on it on the low side because we were definitely getting full thrust.

SCHMITT Yes, in checking the V go versus time chart, you were ahead of that on V thrust. You were getting more than the nominal thrust and that corresponded with our cutoff time.

EVANS Service module RCS - We had no anomalies with any of the quads. The audible cues are not like the simulator, but you can hear some back there. You hear something that's more than the clicking of the solenoids on and off. I don't know what it is, but it's more than the solenoids.

SCHMITT As a matter of fact, it was like somebody in another part of an old house turning on a water faucet and when it's turned off, you hear the water pound against the faucet. I think it probably was the plumbing more than the solenoid.

EVANS Whenever you started a maneuver or were in a maneuver, you could always tell because the vehicle would vibrate a little. The vehicle would move around and when it got to its position, it would sit there and shake a little bit, and then when it started moving, it would also shake a little bit, more than I had anticipated that it would do.

The command module/RCS - We had no anomalies there.

SCHMITT I guess I was impressed by both the service module and the command module firings at the amount of unburned fuel and/or oxidizer that was propelled out of it. My impression was that the command module gave more afterburn material than the service module, but that may be because I was closer to the command module and I watched it. Also, in regard to the service module evasive maneuver after separation, it was very clear what was taking place. You could see those particles streaking out.

EVANS I guess the other thing is, whenever an engine fired at night or on the dark side of the spacecraft, you always got a white flash.

SCHMITT Fuel cells were perfectly nominal as far as I could tell on board, and the ground didn't call anything. The one switching anomaly we had was that, in the process of some activity, one

SCHMITT (CONT'D) of the fuel cell pumps got turned off, and I don't have any idea how that happened. It obviously happened on my watch, and they caught it within 5 minutes.

EVANS Well, I turned the laser altimeter off one time when trying to maneuver to a position to see out the window. My feet were flailing all over the place, and I kicked them off with my toe. I must have. So, I think that's probably the same thing that happened with the fuel cell.

SCHMITT In high power loads, we did see some caution warnings on the O_2 purges, which I didn't expect to see, but it was just barely triggering the high flow. The ground called saying not to worry about it. The batteries were nominal as near as I could tell. I never did quite figure out whether the ground was concerned about the vent pressure after charging because it hung at 0.6 for a long time and then gradually creeped up. They didn't seem bothered enough about it to discuss it with us, so, I ignored it too. It was always within limits. The only thing that I was a little bit surprised at is that they left the batteries uncharged longer than I had expected. I expected more calls. We never really got our entry batteries charged up until the day before entry. We had time to charge them before then. It seemed to me that after TEI we waited

SCHMITT (CONT'D) a long time to get the batteries back to charge, but that's a minor point.

We launched with our batteries down more than normal, so that's probably what started us off in a real-time call in the battery charging because we left battery A charging - I think it was A first - for a long time, practically 24 hours, I think. I'd have to go back and look, but it was a long time recharging. And when we put it on, it carried over 2 amps on the battery charger, which is impressive because in the simulator you never see more than 1. The battery charger was, as far as I could tell, perfectly normal.

Caution warning - Very soon after insertion, we got something like 7, if I remember correctly, before we had comm with the ground again, spurious master alarms. It gradually became evident to us that it was associated with switching panel 2 switches. Ron hit it with a helmet once. It was with the neckring, and he got an alarm. During the pressurization for the first LM entry, we got a couple more. I thought it might be associated with a higher pressure cabinet. That's the only other correlation with that anomaly. I guess after that, we never saw it again.

EVANS Well, one thing we want to mention is that we never got a caution warning light.

SCHMITT The gages - There were no anomalies or power levels that I jotted down at various times to keep track of any possible shorts. Things seemed to be perfectly normal, and anytime it jumped up, you'd always be pretty confident that you could look up and see that the O_2 meter should have come on. There was one time when I thought I saw a major blink on the lights when we weren't expecting any power surge. The ground couldn't find anything on their records, and I suspect it was my imagination.

AC, nothing - I was surprised as I always am, and I've seen it in the chamber that the AC-1 voltages were as low as they were. They are right down at the lower limits, but they're not below the limits. We've asked that question in chambers, and nobody ever worries about it, so I'm sure that's standard.

AC inverters, perfectly normal - We did run inverter 3 for a while as a heat source when the cabin got cold during some of the weird SIM bay/transearth coast attitudes in conjunction with manual control of the mixing valve.

Main bus tie switches, no problem - One surprising thing was the first time I put them on at launch, during the first try

SCHMITT (CONT'D) at launch, the fuel cells apparently were performing much higher than I was used to seeing on the GSE in the chamber. Very little current was drawn from the batteries.

My normal mode of monitoring the bus ties to see if they got it or not was to watch the battery amps, and in those particular cases, I got no indication (for a few seconds anyway) of any amps off the battery. Gradually, a little came up and you could see there were 2 or 3 amps. Then when we checked the gimbal motors. (The batteries were not a good place to check the gimbal motors.) I went to fuel cell amps to check gimbal.

EVANS I always used the fuel cell amps or the O_2 flow.

SCHMITT On the simulator, I always used the battery flow. That's another thing I might mention is that the H_2 and O_2 flow in the fuel cells aren't any good for that because they're too sluggish, much slower than the simulator. The simulator reacts instantaneously to changing loads, whereas the real fuel cells are quite sluggish in their reaction. The sensor bus switch, we turned off once for EVA.

The cryogenic system - The ground was playing games with the H_2 fan because of a thermistor shift, scale change or something like that. We did a lot of manual switching on their call, but that was no inconvenience whatsoever because they

SCHMITT (CONT'D) had a sleep configuration that they could go to and it didn't bother us at all. One thing, it seemed that we, at least as far as the tank pressure was concerned, carried our H_2, $\perp$ and 2 tanks, with us after the service module jettisoned. I don't know why.

EVANS This is a good point to mention, the surge tank was biased a little bit low, too.

SCHMITT That's right, but we were alerted to that. It performed just as the alert specified.

Cabin lighting controls - One thing we didn't use initially but used later on transearth coast was the fixed position being brighter than the maximum on the restat.

EVANS I used that a couple of times trying to get enough light in there to use a camera.

SCHMITT Split bus operations - They worked fine.

EVANS Oxygen masks - We never took them out of the bag. With the gassy situation in there, I was tempted to, but we never did.

We very seldom, utilized the cold water dispenser.

CERNAN Most of the cold water came out of the gun.

EVANS It was handier; that was the reason. You wanted to keep the hot water hot so you keep it going. The water-gas separator stayed on the hot water tap, and we always ended up with gas bubbles generally of about 1/2 to 3/4 inch in diameter in the hot drink or hot beverage, things like that. In the cold water, drink gun, seemed like there were a lot of very small bubbles - just little bitty ones maybe a centimeter in diameter that would end up in the drink gun.

SCHMITT The hot water bubbles were bigger.

EVANS Suit circuit - No problems.

We mentioned the difference in the bias on the surge tank already.

CERNAN The waste management system was all right as far as the CSM was concerned. I still think it's a poor system from a standpoint of hygiene in waste management control. I made that statement in different sections and I'll specifically say any time you use a condom-type system you want to make the valve end of the condom of a larger diameter so that whenever you reroll it for the next use, you can reroll to a larger diameter and get your penis as far up in the system or towards the valve that you possibly can. If you don't, you have to

CERNAN (CONT'D) stretch and pull the condom and half the time your penis might be part way in and half the time it may be all the way in. Any time it's not all the way in the condom, you can almost invariably end up with urine residual in there that has to be cleaned up in one way or another, in spite of the fact that you tend to push it through the valve like it's recommended. The entire system still needs improvement.

EVANS It still needs improvement and in *my* case the condom was *too* small. In other words, I anticipated a shrinkage and the shrinkage did not occur.

CERNAN I did too but I think what I just mentioned would tend to solve that. It's getting it over the head really.

EVANS That's right. That's right. We said everything we want to say about waste management.

We stowed everything in the waste stowage compartment except for two feces.

The CO_2 absorbers - No problems this time. Nothing sticking.

CERNAN Telecommunications - The whole thing was nominal.

EVANS The high gain worked great. There wasn't any problem with that.

EVANS (CONT'D) DSE operation - Ground handled most of it and where the ground did not and the CMP was required, we just said configured and we did it that way.

Tunnel and hatch probes - All operations were nominal with the exception of the things that are noted on the air-to-ground tapes about the docking latches.

SCHMITT (CONT'D) the exception of gyro cal, I think it was Z on the first activation, was slightly out of spec. Not out of limits but just slightly out of spec numbers that were given to me by Jerry Thomas, which was 0.3° spec limit. I think it was 0.5 or 0.6.

Rendezvous radar navigation on the AGS was done in AUTO with the exception of the post midcourse 2, where we put in three sets of marks manually in order to maintain the AGS state vector as close to docking as possible. The AGS state vector did just that - maintained itself within 2 ft/sec and was right with the PGNCS on range at the initiation of braking. Actually it was better than that at the initiation of breaking about 500 feet it was still within two feet per second.

Engine commands - All the engine discretes seemed to get into the AGS. The ground did not mention a single anomaly and I saw none on board. There were no electronic anomalies. Burn programs were perfectly nominal. In monitoring the DOI 2 and the midcourses, the AGS, as expected, did not see the short burst trim pulses that Gene made with the TTCA. The acceleration levels did not seem to be high enough to be sensed by the AGS external Delta-V.

Controls and displays were excellent. After every 400 plus 3 X, PGNCS alined. There seemed to be about a quarter-degree constant bias between the AGS and the PGNCS alinement in pitch and

SCHMITT (CONT'D) yaw. I think it was a combination of pitch and yaw. A little bit of motion on the ball switching from PGNCS to AGS. One further thing on calibration - there seemed to be an accumulating accelerometer bias in X that was well below any significant problem. Probably something like 0.1 ft/sec. I noticed this after the first cal and then after insertion. After insertion I did do an accelerometer cal, 400 plus 7. That seemed to improve the problem although it did not eliminate it completely. It was not a serious problem with the AGS monitoring of its state vector.

CERNAN AGS control check - I checked it out in both pulse initially. I checked all three axes out in pulse. I got the continuous rapid fire pulses. It checked out in three axes. I checked it out in rate command both for command and attitude hold. And it was a very tight system. I checked it out in min deadband only. It was GO. There was absolutely nothing wrong with the AGS system either during powerup or during the phases of checkout.

19.3 PROPULSION SYSTEM

CERNAN The descent burn was extremely nominal in all respects. We monitored the start and attitude hold was steady. I monitored the throttle up on the PGNCS, watched the PGNCS command it, and watched the descent followthrough. It was 100 percent on

19.0 LUNAR MODULE SYSTEMS OPERATIONS

19.1 PGNCS

CERNAN PGNCS inertial subsystem performed exactly as advertised with the initial powerup and with the lunar surface powerup. We did not get a restart light on the initial powerup. That was the only thing we did not get on the initial powerup. The ground said it was a GO.

I was a little disappointed in the AOT. It really performed like the simulator did. I could split the image on the reticle, both on the XY axis and the spiral cursor. By a slight movement of my eye, left or right or up or down, I could place the star within the reticle optical line of sight. I had to try and find a neutral position for my eye on the eyepiece so that I could be consistent in every one of my marks. That bothered me a little bit on the initial alinements until I got a constant position. That's something that, if I flew a lunar module again, I'd certainly like taken care of. The alinements came out good. But they came out good because I found an eye position where the star was focused and where the reticle was focused. I could put the star within the confines of the reticle for a good solid alinement by simply eye movement and not spacecraft or spiral cursor movement.

CERNAN (CONT'D) Rendezvous radar power up and checkout was outstanding in performance during the rendezvous. No anomalies. The landing radar was not only without anomalies, before we started our 70° yaw we started to pick up some indications of radar lockon. I was about halfway through the yaw to the 340 position during the landing when the radar locked on solid. Don't remember exactly what altitude that was, but it was far in access of 35 000 feet.

SCHMITT I think I did two or three PGNCS landing radar checks starting at about 2000 feet. They were within the motion of the tape, exactly on with each other. No anomalies there.

CERNAN Computer subsystem - I utilized the computer exactly like the simulator in terms of verbs and nouns during descent and ascent. Every one of them came up in what I called the prescribed amount of time. We never had any overload master alarms. We never had any program alarms. We never had any anomalous program alarms. It was a duplicate and repeatable of the way I handled the computer in the simulator. Exactly.

G&N controls and displays - The DSKY speaks for itself, The displays that came up on it were exactly what were called for both in the power up in the descent and the ascent. The other two primary displays are the needles and the crosspointers. During descent, the P64 needles again were nominal in terms of

CERNAN (CONT'D) what the simulator told us they would be. The P66 needles in terms of fore and aft velocity were again exactly what I'd seen in the simulator in terms of fly-to needles to null the lateral velocities.

Crosspointers - I matched the crosspointers in terms of forward and lateral velocity with what I saw out the window in P66 for final landing. That is lateral velocity on the crosspointer was effectively zero, and I agreed with that out the window. The forward velocity was probably 1 to 3 ft/sec on the cross-pointer. The best estimation of my forward velocity out the window is that I had some. So, again, they were nominal.

Procedural data - The checklist, in terms of the flow through the power-up through the descent, and through the ascent, were well written. The PGNCS performed exactly as advertised in every respect.

SCHMITT As we said about the CSM checklist, I don't think we had any changes to checklists that reflected any procedural errors prior to launch. I don't think we had any changes to the check-list that I can remember. The checklists worked perfect as far as I am concerned.

CERNAN Let me back up and say something more about the PGNCS. The only time that the PGNCS surprised me was after TPI, when we

CERNAN (CONT'D) had large residuals that I had not seen in the simulator. We had residuals in the area of 7 ft/sec in X and 4 plus or minus a few tenths in Y and Z at the end of the short nominal TPI burn. The simulator residuals were always much less than that. We had no problem. We just nulled them out with the RCS. But, nevertheless, they were there and it was about a 3-1/2 to 4-1/2 second burn. That surprised me just a little bit. We don't have the exact numbers written down because I rolled the residuals right away and went right into P35. I do know they were 7, 4 and 4 plus or minus a few tenths, Prior to descent, they gave us a zero gyro drift compensation. They said the PGNCS was right on. However, right after orbit insertion, it looked like we might have had some g sensitive drift in Y.

SCHMITT You did. The AGS saw it.

CERNAN. For rendezvous navigation and the short rendezvous burn, we did not see any effect of it at all.

SCHMITT The ground tweak was 7 ft/sec and the AGS would show 9 in the same direction.

19.2 AGS

SCHMITT Modes of operation - Nothing off nominal was used. Initialization went perfectly nominal. Calibration, the sighting with

CERNAN (CONT'D) the indicator, on time at 26 seconds. We saw a throttle-down again within a few seconds of that predicted from the ground, but exactly on time with that which we saw commanded from the computer.

The ROD, during the last phase of descent, during P66, responded extremely well. I knew exactly what rate of descent I had simply by the number of clips I put into the ROD.

Descent and ascent was a nominal operation as prescribed and as we saw in the simulator.

SCHMITT The one thing we previously mentioned on caution and warning was that we got a descent quantity light after touchdown by several minutes, presumably due to either fuel sensing or or an actual fuel leak.

19.4 REACTION CONTROL SYSTEM

CERNAN Attitude control modes - I flew it most of the time in pulse. After rendezvous for stationkeeping, nominal operation in all modes, nominal operation attitude hold in AUTO. Translation of control was nominal for ullage and for stationkeeping.

SCHMITT The RCS ascent feed was good. We might add here that we did have a transducer shift in the ascent helium tanks. Tank 2, I believe, was reading hot. I believe that was what the ground

SCHMITT (CONT'D) called it as. They seemed to think they had a mixture ratio problem. They weren't completely sure. They had us terminate ascent feed early. It must have been 5 minutes or something like that. We terminated that early but there was no Significant degradation in our RCS capability.

CERNAN Every explosive device in the spacecraft audible.

SCHMITT Except one. That was the second landing gear. Didn't you say you didn't hear that?

CERNAN No, I heard it too. I could feel it when I hit the switch.

SCHMITT I thought you said you didn't hear that.

CERNAN The first landing gear operation, we felt, of course, the landing gear go out. The second one I could feel, in the switch, the activation.

19.5 ELECTRICAL POWER SYSTEM

SCHMITT The batteries were excellent. There were no battery anomalies. The DC monitoring was no problem. I might mention that the ascent batteries did seem to require longer than nominal warmup time, although I do not believe it was longer than expected with reference to the ground. We unfortunately got started 4 minutes late so we flew the first part of powered descent

SCHMITT (CONT'D) with battery 3 off the line in order to increase the load on the ascent batteries for preconditioning. That was not a problem at all. Battery 3 was put on somewhere in powered descent without any interference with that operation. DC monitor was fine. AC monitor was fine.

Power transfer CSM/LM/CSM went nominally in every case. Abort stage configuration - Nothing to discuss that would be off nominal. Main buses performed nominally and dead facing was nominal.

Explosive devices in all cases seemed to perform as expected. We heard the pyros, I think, in every case except possibly the second set of pyros on the landing gear. That might be expected, not to hear those. We heard the first, but we may have been really hearing the bolts let go and the gear start to move into place.

Voltages were unchanged throughout the whole flight. Lighting - There were no lighting anomalies. Caution and warning - No anomalies. There were one or two configuration caution and warning signals which will come under ECS. What was that caution and warning we got right at the end of descent?

CERNAN Descent?

SCHMITT Right af'ter touchdown.

CERNAN No. All we got was descent quantity.

SCHMITT That was after we vented, wasn't it?

CERNAN No, it was before we vented. The descent quantity did not come on until after we landed and when we went through all the ascent checks. The fuel side was going down all the time. We never talked about it; we never asked.

SCHMITT We don't know why that happened. That's right. The fuel side af'ter touchdown continued to decrease. Sometime into the post touchdown pre-vent checklist, we got a descent quantity light. That was the only caution and warning anomaly.

19.6 ENVIRONMENTAL CONTROL SYSTEM

SCHMITT Oxygen cabin pressure was nominal except for a leaky main A reg, which potentially was caused by having my hoses stowed at one time with the suit in suit flow. That's up to the systems people to decide. But it did reset itself on time. It was not a serious leak. After that time, we did fly with only reg B in use. It was pretty clear that A was a usable reg; it just was leaky.

Cabin atmosphere was good, good ventilation, good odor clearing. The dust clearing was remarkably good, considering the amount

SCHMITT (CONT'D) of dust that we had. It was within a couple hours after ingress. Although there was a lot of irritation, at least to my sinuses and nostrils, soon after taking the helmet off, about 2 hours later, that had decreased considerably.

CERNAN The LCG cooling was perfectly nominal.

The LCG cooling, I think, was a mandatory requirement pre-descent and pre-EVAs. I don't think the air cooling in the spacecraft was adequate prior to descent, which I said a long time ago, back several missions. This was really a godsend. We did not wear the liquid-cooled garments out of our own choice for ascent rendezvous, and I was very comfortable during that phase of the mission.

SCHMITT Yes. I think had you worn them and not had cooling, you would have been uncomfortable.

CERNAN Water supply. My first impression was that, after the first several gulps of water, there was a lot less gas in the LM water than in the command module water.

SCHMITT True. We used all our water. We essentially ran dry at ascent. We drank a lot of water and we even used some additional water on our hands. Water glycol was nominal, and the suit circuit, with the exception of what I mentioned about REG A, was nominal.

19.7 TELECOMMUNICATIONS

SCHMITT There was no problem monitoring the comm system. Operation of S-band high gain antenna was variable. We had some initial problems on the housekeeping day of lockup. It seemed to me to be a ground problem. I don't know their final resolution of that. It seemed that the same kind of thing happened to us on ascent, and again when we came around the horn prior to PDI. It seemed to be a ground lockup problem because it happened on the omnis as well as the high gain. We were just not getting a good strong uplink signal. I don't know what else to say. On ascent, as soon as we lit off, we lost the high gain, went over to omnis, and the omnis were giving the same indications - low signal strength, lots of noise, and a high squeal. Not a real high squeal, but an obvious squeal. It wasn't until somebody else did something that we got the comm back. I did not get the comm back; it just came back. We came through the command module for a little bit. Then they instructed me to do things I'd already done as far as going to the omnis and stuff, and then suddenly they came back up. So, I'm not sure what happened. But when we had S-band comm, it was excellent. Excellent voice.

CERNAN The VHF comm after separation and throughout rendezvous was excellent.

SCHMITT That's right. There was a little bit of a problem close in. I think, again, it was a question of overdriving too much.

CERNAN The EVA antenna operations were all right, but the EVA comm was excellent throughout the first two and a half EVAs. The latter part of the third EVA, I began to get some noise in the background that the LMP did not get. It did not *make* the comm unreadable, but the noise was very evident. That lasted throughout the closeout of EVA-3. The LMP had no significant comm problems on the EVA, and had excellent comm. Procedures and operations of the audio center throughout the LM checkout and EVA changeover setup was nominal. It worked just as advertised.

SCHMITT Flight recorders - I have no idea. I should mention that I probably left the LM DSEA on during the third EVA, because it was barber pole when we got back in. I suspect that we ran out of tape at that time. My regrets to Don Arabian.

20.0 LRV OPERATIONS

SCHMITT LRV deployment was nominal. Didn't we almost slip out of the hinge pins there once?

CERNAN I think they dropped into them. The walking hinges did not drop. They were locked in, as we reported. It seemed to have fallen into the hinges. That was the only time when there was a slight jolt. Throughout the mechanical deployment, which followed the procedures as written, she came down just as advertised and broke loose from the saddle just as advertised. The setup was nominal.

SCHMITT We did have to push the hinge pin in.

CERNAN I went back and reset a forward hinge pin. One out of the four hinge pins was not locked in; the yellow was not flush.

Mounting and dismounting was simply a case of getting acclimated as to know how to mount and how to dismount. The biggest problem with mounting and dismounting was to be able to mount without kicking dust all over the LCRU.

SCHMITT In my case, the problem was keeping a twist out of the lap belt, which made it difficult to unbelt.

CERNAN Mounting on a slide slope aided dismounting.

SCHMITT Almost all in one motion.

CERNAN Vehicle Characteristics - Power-up - when I pushed in the Bravo and Delta circuit breakers, the gages came up just. as advertised. Occasionally, I could feel a little wheel slippage. To the best of my knowledge, I had four-wheel drive and fore and aft steering the entire time, nominal.

The braking action was good.

As a matter of fact, on some of the extreme downslopes we were on, I had to brake continuously and stay below 18 kilometers. We barely hit 18. I had in mind the fact that the brakes could fade on you. We came down some pretty steep slopes at some reasonable speeds, and I had to brake the entire time. I worked the brakes on and off. I had no indication of brake fading at all. I never felt that I was going to lose control because of lack of braking.

Acceleration - Although we could never really go in a straight line very long with the Rover because of boulders, craters, or general terrain features, I drove the Rover full out a majority of the time. Apparently, we were going upslope, especially out to station 2. I was between 10 and 12 kilometers most of the time, and that was at full throttle.

CERNAN (CONT'D) I was a little bit surprised that full throttle did not give me a little bit better acceleration and a little bit better top speed.

SCHMITT I think that 1° upslope was probably there.

CERNAN However, the acceleration when you hit a definite grade or change in grade, you could feel that the capability to climb that grade was always there. In spite of the fact that maybe you slipped down to about 8 or 10 km/hr, you always felt that you had the torque and the power required to make that grade. I never felt that there was a grade that we tried to negotiate that I didn't have the capability to getting over with the Rover. Never.

Steering and Slide Slippage - In 1/6 g with fore and aft steering and four-wheel steering for you, you've got a vehicle that is ready to react the minute you think about putting the command in. Much of the time at the speeds we were driving, as soon as that steering and side slip and sharp turn command went in, you were on three wheels. The reaction was that that you did get side slip. I did feel that the majority of my more rapid or sharp turns, I'd say 50 percent of my driving, resulted in losing the back end on some of my turns. I don't know whether you felt that on the right side, Jack.

SCHMITT Yes.

CERNAN I was comfortable in doing it because I expected it. I felt that in keeping a reasonable speed, the rear end broke loose from me on 50 percent of the turns during my entire driving on three EVAs. It's a vehicle that you have to drive to get accustomed to. It's one you approach slowly, and then you begin to peak out and you begin to live up to its maximum performance capabilities.

You can avoid obstacles very easily. The only hesitancy in doing so is that it requires the same sharp turn and generally your rear end will break out. The turning response is phenomenal.

I was a little disappointed or surprised at maximum speed on what looked like a relatively level surface, which may have been a 1° or so upslope. It was not quite as fast as I thought it might be. Coming down that slope, we did a lot of zigzagging going to different stations. So I didn't get the full brunt of coming back down the same slope. Basically, I felt I could get more top speed out of the vehicle, not that I needed it, but there were times I could have used it in negotiating the surface.

CERNAN (CONT'D) Torque - I don't really think I required more torque. I never lost the wheels going upslope, although I did feel the vehicle working, and you could see it in the amps that you were drawing going up some of those slopes. You could also feel it in the top speed. Again, there was ample torque to negotiate the slopes that we had confronting us. Some of those slopes, subjectively, were quite steep.

Controllability - You had to learn - just like you have to learn on most other vehicles that are essentially like that - to be gentle and smooth during the control. Sharp commands would tend to leave you without the rear end on the ground or leave you with the rear end not exactly where you wanted it. So controllability was excellent, but I felt it was very sensitive.

Crew Restrictions, Limitations, and Capabilities - Displays - I could see and read all displays all the time except when we got dust on the checklist down in front of the hand controller. Then that display became effectively unreadable until I could get off the Rover at the next stop and dust it.

Hand controller operations were as advertised, very similar to the trainer. I used reverse twice, and it worked. I don't recommend it as a standard mode of operation. It's much better to have the vehicle set up for forward only control capability.

CERNAN (CONT'D) My seat and foot rest were, as far as I'm concerned, perfectly adjusted and comfortable as far as position. How about yours?

SCHMITT Fine.

CERNAN Crew Movement Within the Suits - As far as driving the Rover was concerned, I had the same right arm restriction as far as getting my arm back and driving the Rover. But I had no wrist problems as on some of the previous flights. I wore no wrist-lets. I did not rub my wrist raw. I had all the wrist commands. I think that's just a function of where your arms fit in the suit. I had absolutely no wrist movement problems at all. I sat in the suit high enough to be able to see down at the displays and out in front of me. The only restriction I ever had in driving the Rover, out in front, is where coincidentally the last parking angle left the high gain antenna at a planned view. Then I had to look through the high gain antenna. Then the tendency to lose the view beyond was a little bit greater.

Seat Belt Operations - On the left side, I could not have tolerated my seat belt any smaller. It kept me in tight. I felt that I would never lose the Rover. I felt that I'd stay

CERNAN (CONT'D) with the Rover even if we did a 180° roll. Yet it was loose enough to get in and out of. It might be because of just generally getting a little bit more tired, but certainly during the third EVA, I found it occasionally was a little harder to release. How about your side?

SCHMITT Much the same. I mentioned that the seat belt got twisted occasionally. I suspect that made it harder to get out. Being tired, I'm sure, had something to do with that.

Let me skip back up to crew movement within the suit. The only time there was any significant movement was when we were on side hills and moving around all the contours. I noticed I was leaning against the side of the suit, which increased the impression of being on a steep slope.

CERNAN During the lunar Rover samples, the commander was able to take the sample from the LMP and was able to reach over and drop the sample in the LMPs sample bag without any difficulty at all. This was repeatable, based upon ground training. Exactly the same.

SCHMITT The Rover sample worked exactly as we had planned. No changes at all.

CERNAN The vehicle suspension characteristics were outstanding. I negotiated some intentionally, some unintentionally. I negotiated some relatively good-sized rocks, 10 to 12 inches or so, head on with the suspension system and the vehicle just walked right over these rocks without any difficulty at all. I tried to straddle the smaller craters so that we wouldn't get any side slope. In driving the vehicle, the major effort is to deter yourself from side slope activities, whether they're little craters or large craters. So you try and go down through the center of the craters if they're not too deep. If they're small craters, you try to straddle them. We went through some relatively major boulder fields, and the vehicle suspension just accepted it without any difficulty at all. I never felt that we bottomed out. We never bottomed out in terms of the wheels taking a boulder. However, we did scrape bottom once or twice in going over some boulders, centering some boulders.

SCHMITT I never went back to look, but you mentioned you looked like you'd bent a wheel. Is that right?

CERNAN I mentioned something about a golf-ball-size dent in the left front wheel. I inspected all the wheels after that. The left front inboard wheel was bigger than a golf ball. If you

CERNAN (CONT'D) took a fist and just crunched the inner side wall, just punched it and you left an impression of your fist in it, that's about what I saw in that left front wheel. The impression was probably no more than a half an inch to three-quarters of an inch deep and a radius about the size of your fist. None of the other wheels had it because I inspected them after I saw this one. As far as driving characteristics are concerned, you wouldn't know it was there.

Hand Holds on the Vehicle - The hand hold I used most to get in was the low gain antenna on the commander's side to help me to get in a proper position for strap in. Any other hand holds on the vehicle were really relatively useless, particularly in adjusting the high gain and what have you, because the vehicle when it sets by itself was a very unstable vehicle. The tendency to move or shove or lean the vehicle one way or another was very great.

SCHMITT I usedthe accessory stands as my hand hold for mounting and dismounting.

CERNAN LRV Systems Operations - The nav system was excellent. I saw the same characteristic digital movement of the gyro that we saw in LRV sim. But it certainly didn't hamper the operation of the nav system.

CERNAN (CONT'D)

Power Batteries - The temperature on the right number 2 battery was higher at initial powerup. We started powering up at 120°, which I think surprised everybody, including me. It stayed hot, although they both cooled down relatively. It stayed hot throughout the mission. At the end of the third EVA, it was above 138° or 140° and gave us a flag.

Steering and Traction Drive - I wiped out the hand controller as we had planned to prior to the flight about 6 or 8 times before powerup to remove any lubrication problems due to thermal characteristics. The minute I powered up (and you saw it), to the best of my knowledge, I had both front and reverse steering.

Voice Communications and Antenna Management - Antenna management, because of the extensive preflight planning, was excellent. I had no trouble in handling the high gain. I could pick up the Earth and center it. It was there. I just sighted it and looked through, and it was there. I tweaked it up, and there was no problem at all. The low gain antenna, except when we did 360° pans, which I did not bother to adjust at low gain antenna following on the part of the commander to keep us within plus or minus 10° to 20°, was a simple task. It did not require any undue attention.

CERNAN (CONT'D) TV/TCU - Up until the time it failed after lift-off, the TV/TCU worked very well.

Electrical and Mechanical Connections - The only connection I really had trouble with, electrical/mechanical connection, was the SEP connection to the LRV. I had to support the connector bracket with my left hand in order to get enough force on the SEP connector to mate it and lock it to the LRV.

SCHMITT That's the standard EMU connection.

CERNAN That's the standard EMU connection. The only other thing I'd like to mention about the LRV is it's about 99-percent required effort. Even to take a drink of water from the suit drinking bag during LRV driving could put you in some very embarrassing situations as far as following your terrain, craters, and what have you. It was almost 100-percent requirement.

SCHMITT Geology Science Site Response - You've covered pretty well how the Rover performed on various kinds of terrain. Gene, why don't you describe the fender? That was the major dust problem.

CERNAN With the loss of one of the fender extensions, any one of them, the dust generated by the wheels without fenders or without fenders extensions is intolerable. Not just the crew gets dusty, but everything mechanical on the Rover is subject to dust. Close to the end of the third EVA, all the mechanical devices on the gate and on the pallet in terms of bag holders and pallet locks and what have you were to the point that they would refuse to function mechanically even though the tolerances on these particular locks were very gross. They didn't work because they were inhabited and infiltrated with this dust. Some could be forced over center. Others just refused to operate even after dusting, cleaning, and a slight amount of pounding trying to break the dust loose. I think dust is probably one of our greatest inhibitors to a nominal operation on the Moon. I think we can overcome other physiological or physical or mechanical problems except dust.

SCHMITT What we're really saying is that in any future operation, mechanical joints or levers and this sort of thing are going to have to be protected.

CERNAN They should be sealed or protected. We had absolutely no dust problem with the wheels, and those are sealed units. Dust accumulated on the radiator.

SCHMITT That goes for tools too. The only tools we had locks on were the scoop and the rake, and those were getting stiff and wouldn't lock. They wouldn't relock once you adjusted them.

CERNAN The period of time when we had lost the rear fender just put a solid coat of gray dust over everything. Once we got the fender repaired, the dust problem was at a minimum. After the long traverse rides, the radiators all required a good amount of dusting. That required X amount of time. That's going to be required again any time we have a lunar surface operation.

Payload Stowage - Jack, do you have anything? Initially, during EVA-1 prep, I think everything fit under the seats or on the pallet. The pallet fit on the Rover exactly as advertised. The SEP, the deployment of the SEP, the setup of the charges, and the charges on the pallet all fit.

SCHMITT I'm sure we'll get into this in the system experiments, but as a general comment for any radiator surfaces that need to be protected, you need to have more than just a cursory design on the protection of those radiators. The SEP is the case in point, and that was a completely inadequate design to protect those radiators. If we ever do it again in a dust environment, you must have clear and very tight protection of your mirrors and radiators for driving.

CERNAN Something else that dust penetrates that I don't think has been mentioned before is that it penetrates and deteriorates the capability of Velcro. I could see it on the LCRU covers and the SEP covers. The Velcro pulled off to keep the SEP covers closed, but the Velcro that kept them open didn't pull off but it was deteriorating. If you want to use tape on the lunar surface after what you're taping has been exposed to the dust, you first have to clean that surface off with a piece of tape or something and get the mirror dust off before the tape will even begin to adhere to the surface you're trying to apply it to.

SCHMITT We ought to mention here that the gray tape in general is not very good. It will stick to itself, both inside and outside the spacecraft.

CERNAN I had the impression that the gray tape has been sitting around for 10 years. That's the kind of adherence you had.

SCHMITT The tape on the food bags is what we finally used whenever we needed to really tape something. It is much better tape.

CERNAN The gray tape is very poor tape. We covered the stowage, which went exactly as planned. We had no fit problems with stowage or anything on the Rover.

21.0 EMU SYSTEMS

CERNAN PGA Fit and operations - The CDRs suit fit perfectly, including gloves.

SCHMITT The LMPs was an excellent fit,

CERNAN Doffing and donning were just as we expected. The CMP may update this, but as far as we're concerned, he had no gripes or qualms getting his suit on and off.

SCHMITT I think he will have some comments.

EVANS On item 21.0, EMU Systems, everything was normal with the exception of the CMPs prelaunch drink bag. Try and try as I might to get water out of it, I couldn't. After finally getting the suit off in the spacecraft, the drink bag in suit donning had somehow become stuck sideways underneath the neck ring bending the little rubber hose that we drew the water through. It did not allow any water to come through. The drink bag was filled, and it did not expand noticeably from any air that may have been in it. The problem was that it wasn't in vertically. It was kind of wedged in crossways around the neck ring. Everything else from the CMP suit worked adequately.

CERNAN Biomed instrumentation - I think to varying degrees of individuality that we all had sensor skin problems.

SCHMITT Yes, those are documented by the medics. Let me just say that I wore a set of connectors for the whole descent through ascent time frame, and when I took those off in the command module, the electrolyte from a couple had completely disappeared. It obviously reacted with the skin and left sort of a semiscab. It wasn't a bloody scab.

CERNAN The commander had that too. We both had that problem.

SCHMITT If you have the time to change them out each day, it's probably not a bad idea. We just didn't take that kind of time.

CERNAN The LCG operation was nominal. We doffed the LCGs after the EVAs, slept in CWGs, and donned them for the EVAs. It was a very comfortable mode of operation.

SCHMITT I really am surprised that other missions have slept in their LCGs. It just seems to me that this would have been very uncomfortable.

CERNAN Helmet operation - The CDR's was nominal.

SCHMITT The LMP's was fine.

CERNAN You had your visor stuck.

SCHMITT LEVA operation - I did have the sticky visor problem, and it was dust. We could force it closed, once we got it off. We tried once on the surface, and we couldn't get it closed.

CERNAN That was the hard Sun visor.

Lifevest - No comment; nominal. The gloves fit well and tight, and I don't have any gripes.

SHEPARD Did you use the extra set?

CERNAN The extra set is brand new and sitting on the surface right outside the descent stage.

Neck seal - We had no problems sealing the LEVAs, helmets, or anything.

UTCA operation - The CDR used his at every opportunity. I always had a bagful.

SCHMITT I suggest that considerable thought be given to the size of condom that you pick. Mine was too small, and it inhibited the operation of the UCTA. It was a very uncomfortable situation on both EVAs, until I was able to force a urination. After the second ohe, I apparently popped a blood vessel. There was blood, but it disappeared after 24 hours.

CERNAN I ended up with an external scab during the lunar surface EVAs from the sweat,and the condom. It went away.

SHEPARD Was it an abrasion problem?

CERNAN I think it was an abrasion problem. I could not have a larger one because I don't think it would serve the purpose. It was just a lot of work and a lot of walking, and that's all there was to it.

SCHMITT For the third EVA, I stretched the condom and it worked fine.

CERNAN The EMU maintenance kits were fine. We used them as required, as planned.

SCHMITT The drink bags were excellent.

CERNAN Let me say something about the drink bags. We rotated that nozzle 90 degrees. We said it would work in training. I didn't know that drink bag was there until I wanted to get a drink of water. It never interfered with the mikes. I wore it on descent to the surface, on the surface, and drained the bag on all three EVAs.

Ron's bag at launch was doubled up. He can talk about that. They just put it in wrong.

SCHMITT Before you leave the drink bag, there's something down here for the food stick. Neither Gene nor I used all our food stick. I think it was a good idea having it there.

CERNAN I used about half of mine most of the time.

SCHMITT I never felt an extreme desire to eat at all. Every once in a while, I would take a little chunk off of it.

Antifog was fine,

CERNAN There was no fog problem.

The PLSS PGA operations were again nominal as planned. Pressurization and ventilation were good. Liquid cooling was excellent. I never worked for any long duration in high cooling, with maybe one or two exceptions. And generally, I used high cooling only when I was hot and wanted a spurt of cold water. Probably 90 percent of the mission, I worked in medium cooling.

SCHMITT I never went to high, not once.

CERNAN Is that right?

SCHMITT I was in intermediate-intermediate, which is a little better than intermediate.

CERNAN Communications on the surface were good even before we got our antennas extended. I didn't notice any difference after the antennas were extended.

SCHMITT I did, just a little bit. It was a little less scratchy.

CERNAN Connectors and controls were good on the PLSS throughout the flight. They are the one thing that did not seem to get

CERNAN (CONT'D) affected by the dust. They might have gotten a little stiffer, but I could not tell it.

The RCU was good. The RCU fit and operated well. We did not use the OPS.

SCHMITT Let me comment on mine. After the third EVA, we reset the regulator, and that's why we brought the CDR's PLSS back rather than the LMPs.

CERNAN I think Jack activated his OPS with the hose free for just a moment. I think that reset the regulator. Instead of regulating at 39, it then started regulating at 43.

22.0 FLIGHT EQUIPMENT

22.1 CSM

CERNAN The event timers and controls worked excellently. There were nc anomalies, no problems.

SHEPARD Did you have an LEB timer?

CERNAN The LEB timer worked fine the whole flight. During launch, somehow the mission event timer on the main display panel got off. We reset it and it was fine throughout the mission. I don't know what happened during launch to cause that. We never received an explanation.

SCHMITT That's good recollection. You're right.

CERNAN Crew compartment configuration - As far as I'm concerned that is stowage and it was exactly as advertised. We had a few bags that blew up. Once we opened the compartments we couldn't get them back in. I had to stab holes in them, They happened to be the OPKs. I had to take my scissors and punch a hole in seven or eight or the OPKs in order to restall them. When Ron opened the compartment they just went, "plonk." Every one of them blew up. I took the scissors and went klonk, klonk, klonk, to let the air out. The only problem we had on stowage was the OPKs. The mirrors worked fine. The IV clothing and

CERNAN (CONT'D) related equipment worked fine. If Jack and I had one request, it would be to carry one more CWG for cleanliness. Particularly when you come back from the LM as dirty as you are, we could have used one more CWG throughout the entire flight. We had no problems with the IV pressure garments and connecting equipment. Ron may want to mention the g-suit.

EVANS The g-suit was a looser fit than it was when I took off which surprised me. I thought my legs would be fatter.

CERNAN The couches - We got the center couch out and in with no problems. We got the YY struts connected and disconnected many times with no problems. The restraints worked fine. The inflight tool set was really never used except for tool B for the hatch work and tool E for all the continued panel work.

EVANS The ones we used were good.

CERNAN There are a lot of data collection systems. Every one of them that we used, whether it be pen and pencil in the Flight Plan or the DSE, appeared to be working nominal.

Thermal control of the spacecraft - Because of the lack of the PTC control on the way home due to the UV and the IR requirements, the spacecraft was in attitudes where I think it got very cold at times.

EVANS It got cold and damp on the inside.

CERNAN We transferred water from the overhead hatch to the forward hatch and the forward hatch started perspiring. We warmed the spacecraft up by manual setting of the temperature control inlet valve and putting the number 3 inverter on the line. It became very comfortable and we were that way for about 36 hours. Then went back to normal for the entry.

EVANS Camera equipment was nominal. Everything worked real fine. I haven't seen any pictures yet.

SIM bay equipment - The only problem we had was extension and retraction of HF antennas. In all cases, we ended up eventually getting them fully extended and fully retracted. We never did get the retract barber pole on HF 1 throughout the flight. The ground was watching the motor currents and were able to tell when it was retracted. The ground never did get the barber pole indication either on the full retract of HF 1.

SCHMITT I heard Gene say it took 2 or 3 days to get squared away on how to take care of yourself and your personal items. I didn't think it took that long, I think about a day is what you require. I think you should not completely program the first 2 or 3 days.

SCHMITT (CONT'D) You ought to build up to a full flight schedule, for example on Skylab, over the first few days because of the variability in adaptation to the new environment. I think that organizing your own personal items does not take more than a day to really get into the swing of things. I tended not to wear the coveralls the first few days of flight. The first couple days or so I just wore the constant wear garment, but I gradually got in to where I wore the trousers and that was partly to have available the the pockets for odds and ends like PRDs. I felt no thermal discomfort just wearing the CWG until transearth coast when it got much cooler because of the variable PTC attitudes.

The lightweight headsets, I did not use very much until the last couple days of the flight, but when I used them they seem to be perfectly adequate. Ron has probably talked about the problem he had with the headset which I subsequently ended up using only as a cover for my head and used the lightweight comm carrier attached to it.

Medical data seem to go fairly well; it was just a matter of keeping up to date. I did most of it on the translunar leg and Ron did most of it on the transearth leg. It varies whether we use negative reporting on food or positive reporting. It depends on what we've eaten and how much we've eaten.

SCHMITT (CONT'D) Camera equipment, to our knowledge, in flight functioned very well. We understand that we may have had one jammed magazine EE, but at least it transported film for at least half a mag. At the window where most photography is being done, it's useful to have a camera configured for the anticipated type of photography that you would want. Lens configuration, f-stop, and shutter speeds - For the most part we kept the dark slide out of the camera for rapid access to pictures. That was in both transearth and translunar orbit operations.

The kitchen timer, the interval timer I guess it's called, was a very useful item. I had the feeling that it needed a little better time calibration on it. But in using it for the SIM bay operation, sometime you would like to have a little more accurate timing. There's also, I think, usefulness in certain places in the spacecraft to have hook Velcro as well as pile, because hook is useful for hanging up washcloths and other items that in themselves represent a pile configuration. We made considerable use of of the spring bungees stretched across the switch panels in order to not only control the data books that we're using but also to aid in biomed donning by putting all the gear in one spot with the bungee. Also, it was used during eating and to hold the various food packs. We tended to put the food Velcro next to the flight Velcro because it was of a superior quality.

SCHMITT (CONT'D) The gray tape in the CSM is really useful only when you stick it to itself. It does not stick to spacecraft or anything else very well. We tended to save the food pack tape which is much better gray tape than the stowed tape.

We had an adequate amount of tissue, but I think had we had any more problem than we did with the loose bowel movements that we would have run out of tissue. I think you ought to consider that if there's any concern that we may not solve our problems of loose bowel movements that, in Skylab, there should be some way to stow a considerable amount of extra tissue. I think we had just the right amount of towels. It gave us the option of cleaning up at times and not being concerned about using dirty towels several times.

22.2 LM

CERNAN Crew compartment configuration on the LM was as the mockup configuration and as advertised. There were no problems, throughout storage or unstorage. Restraint systems were used for descent and ascent. They worked fine. We used no tools in the LM that I can recall. Our camera equipment had only one aromaly that I know of. A 16-millimeter camera failed to start during ascent. The LMP tried to start the camera in 12 frames per second. He couldn't start it. He had to hold it and it would

CERNAN (CONT'D) run in 24 frames per second. He'll have to describe the details. It did run by itself 12 frames per second later. So we might have to go back and make a check and pick up with Jack on that camera.

SCHMITT The LM crew compartments was fine. We had no trouble except in one incidental case in finding the gear. The restraint system I used during descent and ascent worked fine. We had all the tools that we needed; of course, we didn't need any to speak of. We got by with one pair of scissors both for the cabin and surface operation for the obvious reasons that one had disappeared in the command module.

Again the same comment is that in the LM the gray tape was not adequate.

Camera equipment in the LM was more than adequate. We brought back the CDR surface camera and that was used during the rendezvous for air-to-air pictures and also for air-to-ground pictures and it was used for LM magazines in the command module until we had used up all the LM film that had not been used on the surface for lunar orbit operations. Only half a mag of black and white film was available for use during the post-rendezvous period. I think we used just about every frame of

SCHMITT (CONT'D) film that was reasonably available to us in the flight. We used all the LM film but maybe half a mag of black and white and half a mag of color prior to lift-off. By the end of the rendezvous sequence, we had used up all the color; and then by the end of our TEI, we used up the rest of the black and white for target-of-opportunity pictures. I think it's a serious mistake not to do everything possible to stow more film than you need. We had just the right amount of film. We were conservative about, film usage but not generally conservative. We took all the pictures we wanted. The crew just shouldn't be reluctant to take pictures because that's the prime mode of documentation.

23.0 FLIGHT DATA FILE

CERNAN The Flight Data File was in tune with the flight; it was complete; it was followed; and it was in excellent shape.

EVANS It was in outstanding shape. There was absolutely nothing wrong with it.

CERNAN We had minimal updates to the crew cue cards and minimal updates to the Flight Plan. Flight planning did a super job getting it all together. There's nothing we can add to it. The Lunar Surface Checklist was the one that had most real-time updates and that was simply based on mileages and bearings because the LM position was slightly east of where we had set up the Lunar Surface Checklist. The Checklist was changed in real time because of the time allotted at each station. That's to be expected as the checklist is only a guideline anyway.

23.1 CSM

SCHMITT Generally, I have nothing but praise for the Flight Data File, both vehicles. One comment on the Flight Plan Supplement. We had split pages for medical and food logging. That was probably a mistake. We tended to only use the book as a whole and it was a good place to keep them. If you had wanted the pages split they were too thin to maintain. Furthermore, they tended to fall out of the book, I recommend not splitting the pages

SCHMITT (CONT'D) or having heavier paper if you want them split. I had an extra cue card built for panel 229. I think it was an excellent card that summarized the circuit breaker functions both on 229 and on panel 8. It was not used because we had no systems anomalies of any significance that would relate to that card. But I would strongly recommend its availability if only for training. It's a good quick review of what you lose or retain for those two panels.

In the Flight Plan, I added some pen and ink cues along the margins for certain observational targets that I particularly wanted to look at. These are independent of any designated experiment and I entered them as a function of time. That seemed to work very well for me. I think it is the easiest way to go, since it shouldn't concern any large number of people. Gordy Fullerton fixed up the circular orbital cue card for me with similar designation of craters as a function of time. I did not use that. Not because it wasn't a good idea but because of familiarity with the Moon, which came very quickly after a couple of orbits. You could recognize your position on the Moon fairly easily as a function of each rev, either timing the rev, approximate time since sunset, or just because you could look out the window and could tell where you were.

23.2 LM

SCHMITT The same comments apply. I think all the Flight Data File items were excellent. We logged most of our specific items such as alinement data and comparable kinds of things in the checklist and at the point where they were collected rather than in the Data Book.

Cuff checklist - We talked about that in the surface items. I thought the cuff checklist was excellent.

We had the right kind of photo maps and they were useful for reference when we were around a given station. I don't think we used them as much as I had anticipated.

Navigation was no problem as the points that we had selected previously were excellent points for investigation. There was no need to try to decide on an alternative point to try to study in the vicinity of a given station. The list of items to be accomplished at each station were mindjoggers to read at each station. They were not used as much as I thought they would be initially. That was mainly because we had become so familiar with the items that each station was in itself easy to recall as a result of having created the checklist. So, the checklist was turned out to be more of a learning item rather

SCHMITT (CONT'D) than a reference item for use on the surface. I wouldn't have done it any differently.

I particularly want to compliment Chuck Lewis on the Timeline Book. The book was very very well done and we had no problems with it at all. That of course applies to every checklist we had. There were no procedural errors in any of the books. Fortunately, we did not have to use the Malfunction Book. Only once did I pull out the Systems Data Book to check on a systems problem and I can't remember what that was now.

23.3 CHARTS AND *MAPS*

EVANS I never did use the sun compass. I didn't have time to get it squared away or to figure out where it was and follow it around. I never used it as much as I thought I was going to prior to the flight. After you've been up there for a while you could look out the window and tell essentially where you were, so you really didn't need it. You kind of guess pretty much on the settings for the cameras and hopefully there wasn't any problems in that respect. We used the orbit monitor charts. They are not as good as they could be but were useful in finding out where you were and looking up a few of the craters. I did not use the contingency chart at all.

CERNAN Let me comment about the LM landing site monitor chart and ascent monitor chart. The only time we used these charts was in observing the landing site from the command module on a day prior to landing. Because of the operation of the PGNS and the ascent guidance systems we did not have to use the ascent monitor chart at all.

Lunar surface maps - We used in the cockpit after the EVAs but only pointedly toward trying to relocate our traverse and make sure we were aware of the craters we saw and where we had been. They were sort of a resume-type post-EVA rather than pre-EVA planning guide. Let Jack comment on the EVA traverse maps. I think we used them far less than Jack planned. I used my cuff checklist for all my navigation and for my traverse even though I was told that it would be relatively useless. My cuff checklist was a very vital part of my lunar surface navigation.

WARD What did you use to make the fender with?

CERNAN In that respect, they were very useful.

SCHMITT I thought I would use the orbit monitor charts in the CM, so I had an extra one put on so it wouldn't interfere with the planned activities of the CMP. I did not use that very much. I eventually did some sketching on it post-TEI. I think I labeled about five specific points as areas A, B, C, D,

SCHMITT (CONT'D) maybe E, and these are referenced in my crew notebook for a specific observations.

One item - that chart should have been identical to the CMP's chart. There were a few pen and ink changes left off such as exposure settings for certain photo targets that caused some confusion. The CSM lunar landmark maps that the LMP had added in the rear of that book, again, were not used. As I was observing a specific point or area such as Gagarin I would not take the time out to sketch on the photo. I tended to look at the first opportunity and to take notes in the notebook rather than trying to sketch on the photograph.

I think having selected them and studied them preflight made it worth having them around. The necessity for flying them was probably less than the necessity for having reviewed them and studied them. I still would want to have that kind of data available in the spacecraft. I think the CMP used his visual target maps considerably. I did on a couple of occasions. For the most part, that was post-TEI and I made some notes and sketches on some of those maps. I think that function was because there was a lot of time to look at the Moon make a sketch, and then look back and fix it up post-TEI. In orbit, the time just did not exist. As Dick Gordon said a couple years ago, "Once you start flying, the clock is relentless."

23.4 GENERAL FLIGHT PLANNING

EVANS Outstanding.

CERNAN This may be an appropriate place to comment on how we handled the lunar orbit phase with three men in the spacecraft. After the first 2 hours in the spacecraft, we figured out the most expeditious and efficient way of handling it and it worked that way throughout the rest of the flight. The CDR got in the left seat, where he belongs anyway and took the Flight Plan. Windows 5, 4, and 3 point towards the lunar surface so I let the orbital geologist and the surface geologist look out the windows and make all their finds. I kept them honest on SIM bay, made all the attitude changes that were required, and kept them up to date on all SIM bay switch changes. I ran the spacecraft, they did the orbital geology, and I kept them honest. I kept out of their way. I stayed on my side of the spacecraft, kept the systems and the world honest and they cut loose. That's the way I'd recommend doing it all the time. You didn't bump into each other. Occasionally I would sneak a peek and say they were right or wrong and let it go at that.

EVANS Level of details provided in onboard documentation/recommendation changes - Solo phase - I have no recommended changes. It was in outstanding shape. We had gone through it before and checked it out in the simulator.

CERNAN I want to comment under miscellaneous. I think the Flight Plan carried just enough detail to tell you what was going on and what was going to happen. If you were not familiar with the details of the operation of that particular system or what you were going to do in terms of going into PTC or any other phase in the mission it would refer you to the Systems Book or G&C Dictionary. You did not have to repeat them in the Flight Plan. I like this way of doing things. We generally had the Flight Plan plus two other documents out. One was a Systems Book and the other was probably a G&C Dictionary.

EVANS We kept the G&C dictionary out. In the solo phase, I had the Experiments Checklist out, too.

SCHMITT The Flight Plan was excellent. We had no problems with it at all that I'm aware of. Tommy Holloway and his people are to be complimented. The number of different requirements and experiments and general operational items that were required to be integrated was very very high. It was done in an extremely competent and usable way. I can't think of anything that I would change in the way that the Flight Plan was written.

23.5 PREFLIGHT SUPPORT

EVANS Good.

CERNAN Updated properly. This is both LM and CSM.

EVANS The CSM had no problem. We would give the information to the people at the Cape and they would make the changes in the CSM and quarters copies. We had them in a timely manner. Coordination was good between the Cape and Houston.

Change propulsion system - There were very few changes in the checklists themselves once you came out with the primary book. There were few changes after that.

Real time procedures changes - They were quite nominal and from the CSM standpoint easily taken care of.

CERNAN As far as I'm concerned, the LM preflight support on the Flight Data File was excellent. If there's anyplace that I'd make a comment on it was the fact that somehow the latest changes we thought were in a system somehow never got in until the morning of the sim. They were always there for the sim.

Real-time procedural changes in the LM - There were really none except for the EVA. In the command module, they were so minimal that it was no problem updating the Flight Plan as we went along. I might add that the clock sync was so smooth that you wouldn't even believe that it. It went "zap," we updated our clocks, and we were on our way. That put us right on the Flight Plan and that's probably one of the smoothest ideas anyone ever had.

SCHMITT Excellent in the Flight Data File area. One specific item that I had was two or three briefing sessions on portions of the lunar orbit during which I was in the CSM spacecraft. We went over in detail the attitudes, maneuvers, and the window availabilities so that I was able to plan in a very short amount of time with minimum effort my part for my own personal observations of the lunar surface. I appreciated that extra above and beyond the call of duty on the part of the flight planners. I appreciated their taking time out to do that for me. I think it was useful to have the sessions where the flight controllers, the crew, and the flight planners met and went over those portions of the Flight Plan which were not normally simulated. I was a little bit disappointed in that some of the people who would be eventually intimately involved in the mission were not at the Flight Plan review.

24.0 VISUAL SIGHTINGS

CERNAN Countdown - It was dark and we didn't see anything until S-IC ignition, The CDR and the CMP could see out their small windows in the BPC the glow of ignition prior to lift-off.

Powered flight - During the actual powered flight of the S-IC you could not see anything at all. You couldn't see out the cockpit, as we had the lights up fairly bright. At staging, the S-IC shut down, something that you don't see in the daylight is that the fireball overtook us.

EVANS It sure did.

CERNAN When the S-II lit off, we literally for a nanosecond flew through the bright yellow fireball that was left over from the S-IC. Tower jett was very evident. You could see the flash and I could see the entire BPC. I could see underneath it. It was lit up underneath. The whole thing was lit up. I could see nothing on S-II until S-II shutdown. I could see the glow of S-IVB ignition. I say the glow of S-IVB ignition, it very easily could have been the fireball of S-II which tried to overtake us but couldn't quite make it. But there was a glow right during the period of S-II shutdown to S-IVB ignition. During the S-IVB burn, you could see the glow of the aft engines throughout the burn and throughout the orbital

CERNAN (CONT'D) Earth orbit - I might comment that the availability of stars for a mode II or mode IV abort was pretty poor for two reasons. Number one: night adaptability because we had lights very bright. When we turned the lights down in the cockpit, I could not pick out distinct constellations such as Orion, which I was planning on using for a mode IV abort. If we would have had an SCS and G&N problem it would have been very difficult to pick out stars for that abort.

EVANS I should mention in Earth orbit you couldn't see the stars in the telescope in the daylight but they showed up nice and bright and clear in the sextant. I think that is probably a typical thing.

CERNAN When we burned out of Earth orbit, we started the burn in darkness and flew right on through a sunrise during the TLI burn. This was pretty spectacular. We shut down in daylight and had no other visual sightings at that point in time.

Translunar/transearth - After CSM separation from the booster and docking with the LM several hours later, we could see something which may have been the S-IVB or SLA panels. As soon as we turned around for docking I could see three of the four SLA panels tumbling slowly in space. This is not unusual. That's been seen before.

EVANS I never did see a SLA panel.

CERNAN There seemed to be an awful lot of particles with us continually throughout the flight, both in transearth and translunar coast and in lunar orbit. These particles were obviously residue from the RCS. Others were from dumped residues. They seemed to be hanging around the LM as a result of pulling in and out of the S-IVB and they were always small particles. Some, initially, were pieces of Mylar from the S-IVB LM separation. The others were just like small dump crystals or residue. On the LM, particularly, when you fire the RCS you could see the RCS residue.

EVANS That residue from the RCS didn't look a lot different than a waste-water dump.

CERNAN That's right, except that it's less dense.

EVANS Entry - Just the fireball, and the fireball is a lot brighter than I thought it was going to be. I almost wish I would have had sunglasses. It was really bright out of the rendezvous window just shortly after the .05g when you start picking up the greatest portion of the fireball. That brightness only lasted for maybe 30 to 40 seconds. Then either you became accustomed to the brightness or the brightness decreased. From that point on, I could see the instrument panel. Long

EVANS (CONT'D) after the brightness of the fireball decreased, I could look back up through the rendezvous window and see what to me was kind of like a tunnel with a bright spot in the middle of the tunnel. Way down the tunnel, way back behind, I could see the fireball.

CERNAN The only unusual sighting I can recall during landing or recovery is when the CMP looked out the window and saw the superstructure of an aircraft carrier and said, "Oh, we've got a tin can with us."

EVANS Well, it was kind of foggy on the windows.

SCHMITT Transearth we had only a small crescent of *an* Earth and it was not feasible to do any extensive weather observations. We had light flashes just about continuously during the whole flight when we were dark adapted. I had one which I thought was a flash on the lunar surface. That one period of time when we had the blindfolds on for the ALFMED experiment there were just no visible flashes, although that evening, that night, before I went to sleep I noticed that I was seeing the light flashes again. So, it just seemed to be that one interval either side of it where the light flash was not visible to myself or to the other two crewmen.

25.0 PREMISSION PLANNING

CERNAN Mission plan - A lot of work went into the mission plan, with the right people. I think we came out with a mission plan and a Flight Plan which was not just a suitable one that would accomplish a purpose, but was a suitable one to be able to fly.

EVANS The mission plan was taken care of by a lot of people. The flight planning crew insured that everything in the mission plan was taken care of. And I did not have to participate in that part of it at all.

CERNAN Procedural changes - I think in my experience on past flights, procedural changes were held to a minimum. I think they were held to a minimum because we resisted a great many of them, particularly in terms of the lunar surface activities. Procedural changes if we would have allowed them to infiltrate the system, would have been with us right up to launch date. We put a cutoff on those several weeks before launch, accepted a few of them, and then forcefully would not accept any unless absolutely mandatory after the last 3 weeks. That was the key to keeping that Flight Plan and the lunar surface procedures intact.

Mission rules and techniques - I don't think these changed from any of the previous flights.

EVANS I don't think so either.

CERNAN They were in good shape and followed quite well. The only place we exercised a slight different approach in mission rules was the fact that we had a DOI-1 which did not take us down to the minimum altitude that we had gone to in the past and then a DOI-2 in the LM.

EVANS Let me go back to the Flight Plan here. I think this was the first time we've ever tried this from the command module standpoint anyhow. This was that each person responsible for a section of the Flight Plan, whether it was from LOI to DOI or DOI to circ, was brought down to the Cape and utilized on the simulator console while I or the backup crew ran through the preliminary Flight Plans before they were even in the print stage, We essentially were debugging their part of the Flight Plan. They could see the problems involved and we worked together to get a good plan. This took a day to a day and a half at a time. I think it was well worthwhile.

SCHMITT There were periods of some difficulty, preflight particularly, in the area of medical requirements and in some last-minute possible scientific requirements particularly on the samples, but everything seemed to get resolved satisfactorily. I can't

SCHMITT (CONT'D) think of anything that was not handled very well by the support crew, Bob Parker in the science area, and Gordy Fullerton and Bob Overmyer in the operational areas. I guess the biggest single area that took time was the CMP's dealings with the lunar sounder. Most of our ALSEP changes were all taken care of prior to our training. We had a few minor suggestions, but they were taken care of early in the training cycle.

Mission rules and techniques were fairly well defined very early by Phil Shaffer and his crowd in the techniques area. The mission rules as defined by Jerry Griffin and his people were all in the right direction in that they enhanced the probability of making a landing in a successful mission. We really never had to exercise any of the mission rules in an abnormal way. I think that the one time that a mission rule tended to be a controlling factor was in the limitation on the work at station 4, Shorty Crater. We were up against the walkback constraint and terminated that work after only 35 minutes. Another 30 minutes there would have been extremely valuable. I hope that we got enough information on the phenomena exposed at that crater that can be understood.

26.0 MISSION CONTROL

CERNAN I think the GO/NO GOs and the performance of the CAPCOMs was outstanding. They gave us each GO, both CM and LM. There were no NO GOs, so we received all GOs. Everything was nominal. We received our updates on time. I don't think there was any concern or problem there. Consumables in both vehicles were nominal or better than nominal.

Oxygen - We had plenty of oxygen in both vehicles.

Electrical power - We had plenty of electrical power in both vehicles.

The RCS fuel in the service module was well above the red line for the entire first part of the mission and at or above the red line the last half of the mission. We went in on double ring in the command module and we couldn't have used very much.

EVANS I used more fuel than I would have in the simulator because there were always some rates; cross coupling in pitch and yaw in the command module RCS.

CERNAN LM RCS - We landed with more RCS than I'd ever seen in simulator, well over 80 percent, which made me feel good.

CERNAN (CONT'D) DPS propellent - We landed with between 7 and 9 percent, which is far more than I'd ever seen in the simulator.

SPS fuel - I think came out just about right on the money. We did not make any SPS midcourses on the way home and we had about 3 percent in each side.

The key to the Flight Plan and the key to a smooth operation of the SIM bay in lunar orbit with all three individuals in the spacecraft was the fact that real-time changes were held to a minimum. The Flight Plan was so well thought out and was working so well that real-time changes were very simple, explicit, and not time consuming.

EVANS It was an outstanding way to run a flight. Communications were always good.

CERNAN The only communications problem we had in the LM was right after ascent when we lost the high gain where the ground could hear everything we said. We had a lot of noise and static in the background and we could not hear anything that the ground said until about 3 minutes into the flight.

SCHMITT Typically outstanding support. The number of extracurriculum hours the LM people and the EECOMs for the CSM in particular put in with me on Saturdays and other times just talking over systems, techniques, and mission rules were a major factor in

SCHMITT (CONT'D) helping me understand and keep up to speed. The help that they gave me in designing the emergency cue cards for the LM was a major contribution although we did not use them. Had we required them I think it would have gone very well. I want to point out that Dick Thorson was instrumental in organizing the LM and joint CSM/LM sessions. He was a major organizer for the creation and the updating of the emergency cue cards.

It was *my* understanding that some of the things I had hoped could be done during the flight were not possible because of real-time discussions in the Mission Control. Specifically, one of those things was to have a summary of the thinking of the science personnel in the back room given to me while in flight. The thinking was to be based on the data that we had transmitted to them verbally and visually through the television camera. I had hoped that I would have the benefit of their thinking, but apparently this was not possible. I would like to think that in the future we can look at ways of using the team approach to science investigations in space rather than depending solely on the observational capability and the interpretative capability of the men who are performing the job. There is no reason that I can see not to use all the brain power that is available at any given task, and part of that brain power is on the ground.

27.0 HUMAN FACTORS

27.1 PREFLIGHT

CERNAN Preflight health stabilization and control program - I guess it was adequate. We stayed healthy; we came back healthy. Medical care was adequate. Preflight time for rest, exercise, and sleep is something that only the crew can provide for because there's never enough time to train. When there's not enough time to train, then there's never enough time to get adequate sleep, rest, and exercise. It requires a certain amount of scheduling and crew discipline to get it all in. I believe that we got it in. Adequately prepared physiologically for the flight at lift-off.

Medical briefing and exams - After extensive preflight work for several months prior to the exams, I think that they eventually ran relatively smooth with the exception of a few misconceptions over the use of the lower body negative pressure in the CMP's G-suit garment, which eventually got resolved.

Eating habits and amount of food consumption. Preflight - I think the crew has no gripes. We were satisfied.

EVANS It was good.

CERNAN The medical department was satisfied and we were satisfied.

SCHMITT I personally did not find any great difficulty working out or adhering to the requirements. Medical care, although a very limited requirement, was good. I had a couple of sinus infections that reacted as they always had, and we were able over a period of 10 days or two weeks to get those cleared up.

Time for exercise was probably less than it should have been, although I was able to get a good workout about every other day in addition to the workouts we got as a normal course of our EVA training. Eventually Tex started scheduling a pretty normal schedule time in the late afternoon for exercise. That helped as a reminder to see that that exercise was obtained. It is hard, at least in the lunar training program, to get in exercise periods during the day. Quite frequently, the exercise was done in the KSC gym at night. Rest and sleep is an individual thing. I made a particualr effort to always get as much as I possibly could and never get behind the power curve on rest. My personal experience is that I tend to get colds and resulting sinus infections.

SCHMITT (CONT'D) Medical briefing was good. The exams seemed to go very well in my estimation. They were as expeditious as possible under the circumstances. I think the operational medical personnel who carried out the exams are to be complimented in their efforts to see that the exam was as painless and as efficient as possible. This should also include the postflight exams on the Ticonderoga.

Eating habits and the amount of food consumption were normal except during those periods when we were on the inflight food prior to launch. Those times tended to decrease *my* appetite, although the food was certainly tolerable. It was not possible for me to eat the amount of food that was provided for me. This also applied to space work in the case of the inflight eating. Although I did not eat everything that was available in my food packages, I apparently needed to if I wanted to avoid losing weight. My appetite was down and I had a loss of weight. At the time of this recording, *my* weight has not yet gone up to preflight levels, which may have been a little high.

27.2 FLIGHT

CERNAN Appetite and food preference.

EVANS Appetite in-flight versus 2-week preflight - I don't think there was any change for me after the first day and a half.

CERNAN My appetite normally inflight, based upon past experience, will decrease markedly versus nominal preflight activity. Everything else being consistantly nominal, I would probably have to force myself to eat because the requirement is there to have that energy and food, but the appetite would not necessarily be there. This is just typical of me. In this particular case, the food as expected, produced a great deal of gas. For the first part of the flight, it was unpassable gas which resulted in a big football-like knot in the stomach which ranged in degree from inconvenience to annoyance to disturbing and downright painful in some cases. That also degraded the appetite because every time I ate it just stimulated this particular problem.

Difference notable in food tastes inflight versus preflight - I think the greatest difference is that there is always some gas in the water. One of the biggest problems in preflight

CERNAN (CONT'D) is that you always have someone like Rita Rapp to prepare them and the inconvenience part of the job is done.

EVANS I didn't notice any real difference in food taste in flight versus preflight. To me, the wet packs taste like canned food, and the rehydratables had a better taste.

CERNAN It is obviously a very individualistic thing.

EVANS That's right; it's an individual thing, and I don't think it makes any difference whether from the first day on.

CERNAN Your food preference changes as to how you feel that day. If you see a package of shrimp cocktail that doesn't look very good, you don't rehydrate it; you don't want to eat it. And, as far as I'm concerned, I could eat 10 wetpacks to every rehydratable pack.

EVANS The first days when I really didn't feel like eating, I really didn't want the wetpacks. I would rather rehydrate something, because, to me, it had a better taste, because it didn't smell I guess. The smell of the wetpacks, when I really wasn't hungry, and still acclimating to zero-g flight on the first, day there, didn't appeal to me at all.

CERNAN I'm going to say again that the size of food portions and meal portions is a subjective individual thing. As far as I'm concerned, the food portions are entirely too great. The entire meal portions were too great and too large. I lost my 9 pounds. I predicted I'd lose somewhere between 8 and 10 pounds, and I just don't feel like I can eat as much food as there was to eat on that flight. Even though I ate more and more as the flight progressed, I very seldom consumed the entire meal that was presented at any given time.

EVANS In my case, I think, most generally, I ate just about everything. However, if you didn't have time, which, in my case, it seemed to me like there were times when I really didn't have time - once you get all that stuff ready and it gets on through there, you really don't have time to eat everything. So you, hopefully, try to get everything made and have time to go ahead and finish everything except maybe one package.

CERNAN Food preparation and consumption - Programs with rehydration (mixing and gases) - There is gas in all the water, and there appears to be a little more in the hot than in the cold. We added more water than was called for to make up for the amount of gas in the food. When I ate the food or drank the beverages with gas in it, I could expel it through my teeth, and not

CERNAN (CONT'D) drink the gas, and still get the liquids out of the rehydratables. I don't really feel I drank or ate much gas out of the water, by comparison to what I could if I just swallowed everything that was in the package.

EVANS In *my* case, I swallowed everything. I never consciously tried to separate the bubbles and the water. I guess if you got an obvious bubble on the thing, you normally don't swallow bubbles; at least, I don't think I did. In the spoon-bowl packages, if you had a bubble in there, when you opened it up the bubble was gone, so there's no problem with the spoon-bowl packages. In spoon-bowl packages, the bubbles all developed in one big bubble, and you could break that one and have no problem at all with the gas in it. The hot water had more gas bubbles than the drink gun, Maybe they were smaller bubbles; let's put it that way.

CERNAN Food temperature - There's no question that the hot water, and it was always hot, was an excellent way of preparing the rehydratables that are desirable hot. In the LM, you did not have the privilege of hot water, and the difference in eating LM food with cold water, after eating some of that nice hot-water food in the command module, was very evident. There are some of those wetpacks (hamburgers, beef steaks,

CERNAN (CONT'D) what have you) that, some way of heating them up, an oven or some other way, would increase the palatability of the food immensely.

EVANS Let me second that statement, for sure.

CERNAN Effect of water flavor and gas content on food - I don't think the flavor was any different than what we've seen in the past. The rehydratables are very closely attuned to the taste and flavor of regular table food, but they're never quite the same.

Use of spoon-bowl packs. We used those quite frequently, and I thought, for the most part, they worked out very well. We did something different with the soups or the more liquid spoon-bowl packs. Instead of actually opening them up and eating soup with a spoon, we just cut off the end from which you rehydrate them and suck them out. The lumpy foods, like the potatoes, we of course ate with a spoon.

EVANS Let me make one other comment about the spoon packs, the cereal portion of it. I didn't feel like I wanted to suck the cereal out through a little hole in the thing, so I always opened those up. In general, those seemed to be the ones, in order to get them properly rehydrated, you ended up with the biggest bubble in the middle of it. So every time you tried to open

EVANS (CONT'D) one of those things, it was a messy operation. When you first opened it, it had a tendency to run right up the edge. If you tried to open it slowly, it would definitely run up the edge. If you tried to open it fast, you'd almost push it out.

CERNAN The other thing about spoon-bowls - when you were finished and you put the germicidal tablet in them and you tried to seal them up, they'd have a tendency to produce waste along the sealing edge. Then you'd have to suck it off or wipe it off, or you'd have bubbles of soup or whatever was in the spoon-bowl floating around.

Opening a can - Puddings and nonliquids were fine, but when you come to the mixed fruits or the peaches, or this type of thing where you have liquid, those cans are great once you get them open. The thing about it is when you break the seal, you break it into the can, and it's not that the can is pressurized. You break it into the can, you reduce the amount of volume, and you force liquid out. It comes off the can in bubbles and you have a mess. You end up having to be very careful. If those cans would open entirely outward instead of inward, you'd reduce that mess.

EVANS I finally got to where I could stick the can in my mouth and open the can with my teeth.

CERNAN And he sucked the juice out as he opened it, which is a very poor way of doing it.

EVANS Poor, and kind of hard on your teeth.

CERNAN Food bar usage during EVA period - The CDR and the LMP found their use very gratifying, very easy to use. The CDR, for the most part, ate from half to three-quarters of his food bar each EVA. The LMP really hardly ate any of his at all.

Food waste stowage. Function of germicidal tablet pouch. We always had a couple of pouches around the spacecraft, stuck in corners, so that we could get to them every time we wanted to. We had the Skylab waterbags on board, and we had these small little valves in the waterbags. So I think from about the second day of the mission on, all three crewmen, (when we drank juices, regularly prepared juices), would rehydrate them with that same valve that we had on the water package. Rather than cut the other end of the juice bag off and suck the juice out through a flat plastic end, we'd use that Skylab waterbag valve, put it in the same hole which we rehydrated the juices out of, and drink it that way. We found it was less messy, easier to drink, and. convenient to consume. And, I recommend that Skylab waterbag for all the juices. It's a neat little bag.

EVANS It sure is. It's a neat bag; it's one less cut on the thing; and it's great.

CERNAN Food waste stowage - We used germicidal tablets in most all the foods. We passed up a few juices sometimes, because in drinking juices the way we just described, you had to cut off another corner of the juice bag in order to get the germicidal tablet in.

EVANS I never did put one in the juice bag.

CERNAN I put some in some of them.

Undesirable odors - I don't think there were any undesirable food odors. They were overwhelmed by the urine and feces odors and the gas odors in the spacecraft.

Quantity of food eaten on lunar surface - I think probably the appetites on the lunar surface were very good. It did not appear that the food was packaged individually for CDR and LMP, so we broke out the food for that day, laid it on the table, and had a family dinner out of what was there.

Quantity of food discarded on lunar surface prior to lift-off - I don't think we discarded any uneaten food on the lunar surface, although we did leave some uneaten food in the lunar module prior to jettison, but not very much.

CERNAN (CONT'D) Water - Chlorine taste and odor - We never had a chlorine taste in the water, and we did chlorinate every night prior to going to bed.

Iodine taste and odor - The LM water was good. We did not take a filter.

Physical discomfort of gas in water - I think the LM water had quite a bit less gas after the first cupful taken out of the LM descent water. I think we had much less gas in the LM water than in the command module.

EVANS The only comment I want to make is that the gas/water separator that you stick on the food preparation bags always leaked like a sieve. You had to keep the cap on it at all times; otherwise, you'd end up with a big blob of water on it. The cap was quite effective, though, in stopping that blob of water from forming.

CERNAN Intensity of thirst on mission - I think the known need for staying hydrated was there. Although I drank more and more water as the mission went on, I think that there was never really a strong intensity of thirst that plagued me, except on the lunar surface after we got back in the lunar module and I found myself drinking water continually out of the water

CERNAN (CONT'D) gun, prior to EVA and post-EVA. So, I think I consumed, on an average, probably twice as much water in the LM per day as I did in the command module.

EVANS I was hustling around doing a lot more physical activity in preparation for the EVA, and at that point in time I was thirsty. I wanted to have a drink all the time. But the rest of the time I really wouldn't get that thirsty. But, you just felt like you ought to have a drink of water, and you'd drink as much as you could.

CERNAN Work-rest sleep - Difficulty in going to sleep - I think all three crewmen experienced varying degrees of difficulty with going to sleep, and all three crewmen utilized Seconal at one time or another. The commander probably had three Seconals, and they were all taken prior to hitting the lunar surface. The CDR did not take any Seconal, to the best of his recollection, on the lunar surface or any time thereafter. I got excellent sleep when I did take a Seconal; when I did not take a Seconal, sometimes I got excellent sleep, sometimes I got marginal sleep.

EVANS I think I probably took Seconal more than anybody up there. I'd have to look in the Flight Plan to find out for sure how many days I did not take. But I'm guessing 4 or 5 days I

EVANS (CONT'D) probably did not take Seconal, the rest; of the time, I did. And, most of the time when I did take Seconal, I would sleep for 3 to 4 hours straight - just go to bed and go to sleep right off the bat - sleep for 3 or 4 hours and then kind of wake up, off and on, from that point on. Normally, when I'm around here, I require about 7 hours of sleep per night, and every once in a while 8, in order to feel real good. Up there, it seemed to me like I could get by quite adequately on 6 hours with no problem at all.

CERNAN The sleep restraints were used every night in the command module by two crewmen when there were three men in there. The third man slept up in the couches. I thought they were adequate to help keep the temperature comfortable.

EVANS When I was solo, I always slept in the sleep restraint in the capsule. The first night I put the lap belt on just to keep me from floating all over the thing. The rest of the time I didn't even bother with the lap belt; just jumped in the bag and floated wherever I happened to float around the spacecraft.

CERNAN That's the same thing that I did when I was sleeping up in the couches with three men in the spacecraft. I just put the restraint on and floated around. It didn't bother me at all. In the LM, although my hammock was as tight as it would stretch,

CERNAN (CONT'D) it still rested upon the suits in 1/6g, which was no problem. I thought it was extremely comfortable sleeping and, as far as I know, the LMP had no problems with the sleep restraints. A very good way to sleep in the LM, considering the tight quarters. The best thing we did was shorten that first day after launch, particularly in light of the delay, and put us on a reasonable Houston work-sleep cycle. It gave us sort of an extra day to a mission, but it put us on a very compatible work-sleep cycle, and it kept that first day to a minimum and set the rest of the days keeping pace with it. I felt very strongly that we get 8 hours of sleep period. When there were days when we were late getting to sleep about 30 or 40 minutes, I requested and got an extension of sleep period the next day. When the day had to be something very critical, like PDI day, I made sure that at all costs we did get to bed and we did get our full 8 hours of sleep. I think this probably paid off more than anything else. On the way back, after the more important aspects of the mission were complete and we got to sleep half hour or hour later, I made a decision that we'd just stick with the Flight Plan and get up on time. So it may have shortened our sleep period to 7 hours, 6-1/2 or 7-1/2 hours in some cases, but that worked out fine also. Prior to the major objectives of the mission, I felt very strongly about preserving that 8 hours, and we did.

EVANS I was going to say I agree completely in that you need to get started as rested as you can.

CERNAN Disturbances - Typical spacecraft disturbances when one man moves or one man sneezes or when one man does something else - every man does it because you just live in that kind of an environment. The CMP is the only guy that can sleep through master alarms, crew alerts, buzzers, anything. About 3 nights out, prior to coming home, he starts talking in his sleep. He was up on the couch on duty that night, and I heard "Houston, Roger" and "Houston, this is America." Then I realized you were talking in your sleep. And then it dawned on me, supposing he decides to make an SPS burn? I stayed awake all night long listening to him.

CERNAN Exercise - I think the frequency of exercise on the way out was more consistent than on the way back. We exercised every *day* on the way out, for periods ranging from 10 minutes to 30 minutes on an individual basis. The quality of exercise I thought was pretty good. In some cases, the heart rate could be monitored on the ground; in other cases it was not. But in measuring your own heart rate on board, I think for the most part we all got up, consisting for periods of time, to 110 to 120 beats per minute. The exerciser - I think Ron and I used the exerciser for a couple of days on the way out.

CERNAN (CONT'D) We talked about the exerciser in the spacecraft. It was used on the way out to the Moon on just a couple of separate occasions by the CMP and the CDR and it worked adequately. I didn't find any problems with it. But I think I exercised more efficiently by sitting in the commander's couch, holding on to the arm struts very tightly, and holding myself against the LEB bulkhead and running in place to produce artificial-g. I was working *my* arm muscles and I was running against the bulkhead, which produced force against *my* legs. I could really run at different speeds and for long durations, and that's the way I did all my exercise. The LMP did his exercise that same way and he did it on the right-hand couch. I don't know how he found room to move his knees, but that's where he did it.

SCHMITT I wasn't too concerned about my legs, so I just kind of let the legs go. I really didn't exercise the legs at all except for one time. The rest of the time I was essentially trying to exercise the arms, so I used the exerciser twice, I think, by grabbing hold with one hand and pulling it through as much as I could, back and forth, that way. Then, as Gene did, I figured out I could grab hold of the struts on the spacecraft, put my feet up in the tunnel and squeeze the struts in one way and turn the hands around and push them out. I could really work up an exercise by just kind of shaking the strut as much

SCHMITT (CONT'D) as I could. I could actually work up a sweat just doing that type of operation.

CERNAN Muscle soreness during or after flight - There was none on anyone's part after the flight. As far as I know, certainly on my part, there was none during the flight with one exception that I'll mention. I felt (and I don't know what the metabolic assessment is from the data that came down) that when I got to the Moon there was little or no degradation in my physical capability to do the job. I felt neither short of breath nor short of muscle response or anything when I got to the surface. The only comment I want to make, and maybe it's not muscle soreness, is that after the first EVA, both the LMP's hands and my hands were extremely sore from all that particular type of hand-dexterity labor that's required with the ALSEP and with the drill. There were no particularly abrasive areas. The fingers and the hands were just sore from continual movement, to the extent that we both had, on both hands, several blood-blister-like formations under the fingernails. We both felt a discomfort after that first EVA. The second EVA, it was less; the third EVA, it was less; and by lift-off my hands were perfect. They did not in any way hamper anything I had to do during that first EVA. I didn't even know they were sore during the first EVA until after I got

CERNAN (CONT'D) out of the suit. The second EVA, they didn't hamper anything, and the third EVA, they got better still. It's like maybe having a muscle that needs work and that's what it amounted to. And the LMP's were the same way. His were bothering him the first EVA, and the second EVA they were better. It had nothing to do with the fit or size of the gloves. If I have to get a pair of gloves, I would get them fitted and sized the same way I got these fitted and sized.

EVANS I'd like to mention one thing on muscle soreness that I heard about in preflight. I think the soreness in the back is not the lower back. It's just the muscles in the upper part of the back. I think this is from sleeping. I don't think it's from trying to hang on to something. I think it's trying to get a relaxed position in the first part of flight, because I think it's hard to pick a relaxed position with your legs. You tend to kind of hold them in one position or another. Later, on the flight, I didn't notice that at all, and I didn't really recall trying to hang on to something. The only time I can recall trying to hang on to something is during the solo orbit periods when I was trying to focus on the camera out the window. During this type of an operation, I really used *my* feet to hang on to things and my back wasn't sore then.

CERNAN Perspiration during nonexercise periods - I don't think there was any on anyone's part. During exercise periods, I found myself right at the threshold of beginning to perspire, but never really felt like I was.

Inflight oral hygiene - I had no mouth discomfort. I brushed at least once a day and probably twice a day, once in the morning and once at night. I never used dental floss, and the toothbrush and toothpaste were certainly adequate.

EVANS It felt like you needed to brush your teeth every now and then. If I have to do it again, I would get my teeth cleaned prior to going on the flight. I didn't this time for some reason.

CERNAN Do you think that has anything to do with your smoking?

EVANS Maybe it did. I don't know. But it felt like I really needed to have my teeth cleaned. I felt that way before flight so . the flight has nothing to do with it. Brushing frequency - Probably at least two or, most of the time, three times a *day.* Never did use dental floss. The toothbrush was great; I had no problems swallowing the toothpaste. Tasted pretty good as a matter of fact.

CERNAN Sunglasses or other eye protective devices - For some strange reason (I would never have believed it) but I took the sunglasses out of my pocket once, put them on for about 20 minutes, and never used them the entire flight.

EVANS The first day I didn't use them at all, and my eyes felt a little bit like maybe they were getting a little bit red or something, just a little bit tired, so I put some eyedrops in. The next day I got my sunglasses out, looked out the window a couple of times, and then needed to look at the map or something back inside. I put my head down and couldn't see the map, so I had to take the sunglasses off. So I finally said heck with it. I didn't wear the sunglasses the rest of the time. In a good portion of the visual observations, I felt that color was an important part of it. If I had sunglasses on I couldn't get a true picture of what the color is, so I didn't wear them.

CERNAN Unusual or unexpected visual phenomena or problems experienced - I focused during rapid acceleration or deceleration with no problems.

EVANS No problems with me.

CERNAN Visual details - Sunlit versus down-Sun areas - Let me talk surface, and you can talk about orbit. Driving the Rover down-Sun into the west was a very degraded operation. There was no way that you could do any shadowing. We did it for a great part of the time. You just had to sort of look through the down-Sun effective zero-phase area to make sure you could see

CERNAN (CONT'D) what was coming up. Driving up-Sun, again, was a degraded mode of driving. It was very bright. Everything that you were looking at was effectively washed out. But when you drove up-Sun you had a capability of either shielding your eyes with the hard-cover visor or your hand. As soon as you did that, you had absolutely distinct and perfect vision as to what was ahead of you. It was a case of being able to have the right geometry of the Sun versus your direction of driving.

CERNAN Vision without outer visor during EVA - In effect, I never used mine. I used the protective visor and the gold visor almost the entire time except when I was in the shade and I lifted my gold visor. I hardly ever, except for occasionally driving into the Sun mode of operation, used the hard-cover visor at all. I never used the side hard-cover visors and just very seldom used the center hard-cover visor.

Distance judgment versus aerial perspective during EVA - The size and distance you certainly had to multiply by a factor of 2, and maybe I would go so far as to say a factor of 5 in many cases, because there are no references on which to base size or distance.

Well, I think the Moon horizon and the Earth horizon at sunrise and sunset have been discussed in detail in the past, but there is nothing unusual experienced which I didn't expect.

CERNAN (CONT'D) Eye irritation during photos at window and EVA - I never wore sunglasses and in effect never had any. I take that back. One day, prior to PDI day getting in the LM, my right eye started watering for some reason but did not impair vision. I put some eyedrops in it and it seemedto soothe it. I never did anything else to *my* eye again until, one day on the way home, I got some chlorine in it, and I washed it out and put some more eyedrops in it. Beyond that, I had no eye irritations at all. We had chlorine all over that spacecraft. That's the way I washed my hands everyday, chlorinate the spacecraft.

Helmet visor reflections - I had no particular problems with the helmet. My gold visor got very dirty and dusty and scratched up very early in the first EVA, and I cleaned it as the ground prescribed before each EVA, but it really didn't do much good. I just learned to live with it, and it really didn't degrade the operations much at all.

EVANS Well I think most of these are pretty much not applicable to lunar-orbit-type stuff. I used your LEVA and I didn't even notice any scratches on the thing while I was out. Unless you want to talk about the eye irritations during the photos at the windows. This was essentially on the first day in lunar orbit, I think. And, for some reason, I never even noticed it from then on. I never did use the eyedrops from that point.

CERNAN Medical kit - An adequate quantity of medications was supplied. I think there were certainly adequate quantities of medication in both vehicles. We brought the medical kit back from the LM. Why I don't know, but we did bring it back. Yet, in spite of bringing it back and having the command module kit there, we ran out of biomed sensor electrolyte sponges on the last day of the flight.

EVANS The sponges themselves are packed in packages of six, so you throw one away every time.

CERNAN I will say one thing. I did change my sensors one time on the lunar surface. The sponges in the LM medical kit were about half the thickness or a little bit better than half the thicknesses of the sponges in the command module medical kit. So when I put those sensors on, I put two sponges under my sensor instead of one because I didn't feel that one sponge would do the job. Two sponges were just a little too much, but I did use two sponges. Packaging of the kit was fine. Adequate instruction for use - As far as I'm concerned, there is no instruction for use on anything in the medical kit. If you want to take a Lomatil, there is nothing that says diarrhea. You don't know whether you can take one, you don't know whether you can take two. If you take two, you don't know whether you can take a Seconal with it. So, effectively, there are zero

CERNAN (CONT'D) instructions. Even if the instructions were there, I'm sure you would have to talk to the ground before you take them away.

EVANS We'll talk about the EKG on the thing. Let me make a comment. To me, we changed those things way too often. You had it on for 12 hours and you took it off and the next day you put the crazy thing back on again. If you've got it on, keep it on for 24 hours, something like that. Then let the other guys have a 2-day break on it. If, you're going to cycle it that way, don't keep changing the thing every 12 hours.

CERNAN One thing about the sensors - Sometimes it's more inconvenient to change the sensors than it is to keep them on. Much of the time, where the guy was going to take them off rather than go through the inconvenience of taking them off and cleaning them up and getting them prepared and putting them on, whenever he had to put it on later, he'd just leave them on throughout that period.

Housekeeping continues to be the major operation of space flight, particularly in spacecraft as small and as requiring as the command module and LM. Maybe in Skylab it's going to be more so, because the spacecraft is bigger. Changing sensors, for instance. As soon as you change one sensor, you've got about four or five small, loose articles in your hand.

CERNAN (CONT'D) You've got to contain them. You've got to put them in a small garbage bag and then eventually put them in a big garbage bag, and every time you have a loose article with no place to put it, it's a housekeeping problem, automatically. I don't know what else you can say about that. The thing that was good as far as the command module is concerned was that we had an extra temporary stowage bag that we put up in the tunnel. That was kind of a temporary jettison bag that we filled up. As soon as it got full we would stick it into a big jettison bag and shove the jettison bag underneath the couch somewhere. It's an effective way to keep track of the junk and the trash because it's got a spring-loaded door and you shove this stuff up in the bag.

CERNAN The thing about housekeeping is that it takes you anywhere from 1 to 3 days to effectively unstow the spacecraft to get at those things you need on a cyclic-type basis. Those things you need to keep living, eating, sleeping, and working with. And you have to find convenient temporary secure stowage locations for all these things. No one can really dictate whether it's going to be particularly convenient to you; but; once you do this, your housekeeping problems begin to minimize. But it's just a case of setting up those living accomodations which are compatible with three individuals who are trying to live compatibly

CERNAN (CONT'D) together, both in taking care of their personal items like spoons and toothbrushes and taking care of spacecraft operational items like cameras and chlorine packages and filters and what have you. It's too inappropriate to put a lot of those things back in their original launch stowage configuration position.

Shaving - I shaved once before PDI, once after PDI, and once before reentry, and I think it's one of the most clean feelings a guy can get in the spacecraft.

SCHMITT It's great. I could only shave about a third of the face at a time, maybe a fourth, so that's the way you do it. You put a little bit on and shave that part off and start again. I've got a recommendation on the razors. And Gene didn't have that problem. I guess my beard is a little thicker or something, but I couldn't use a two-bladed razor. I could get one scrape out of the thing and it was full. There is just no way to clean it out and it just wouldn't cut anymore. The single-blade razor is the one that evidently has enough room in there. Even though it got plugged up with the shaving cream, it still worked okay.

CERNAN Dust - I think probably one of the most aggravating, restricting facets of lunar surface exploration is the dust and its

CERNAN (CONT'D) adherence to everything no matter what kind of material, whether it be skin, suit material, metal, no matter what it be and it's restrictive friction-like action to everything it gets on. For instance, the simple large tolerance mechanical devices on the Rover began to show the effect of dust as the EVAs went on. By the middle or end of the third EVA, simple things like bag locks and the lock which held the pallet on the Rover began not only to malfunction but to not function at all. They effectively froze. We tried to dust them and bang the dust off and clean them, and there was just no way. The effect of dust on mirrors, cameras, and checklists is phenomenal. You have to live with it but you're continually fighting the dust problem both outside and inside the spacecraft. Once you get inside the spacecraft, as much as you dust yourself, you start taking off the suits and you have dust on your hands and your face and you're walking in it. You can be as careful in cleaning up as you want to, but it just sort of inhabits every nook and cranny in the spacecraft and every pore in your skin. Although I didn't have any respiratory problems, I think the LMP, which he can comment on later, had some definite local respiratory problem immediately after the EVAs due to the dust in the cabin.

CERNAN (CONT'D) In sputum - I didn't spit up anything. I didn't feel any aerosol dust problem at all until after rendezvous and docking when I took off my helmet in zero-g and we had the lunar module cabin fan running the whole time. I did all the transfer with my helmet and gloves off, and I'm sorry I did because the dust really began to bother me. It bothered my eyes, it bothered my throat, and I was tasting it and eating it and I really could feel it working back and forth between the tunnel and the LM. Ron, did you feel any effects of the dust when we docked and rendezvoused, particularly?

EVANS Only when I stuck my head up in the LM. When I climbed up in the tunnel I could definitely tell there was a lot of dust up in the LM and you could smell it. It's a difference, so I think you noticed it from that standpoint, but there never really was dust in the command module. The only time you ever got any dirt in the command module was when you touched something that had dirt on it. But as far as dust floating around in the command module - I don't think it ever did.

CERNAN After rendezvous and docking - After the CDR and LMP had been living with this dust for 3 days on the lunar surface, there was a compelling urge on both of our parts to get clean. We spent about 2 or 3 hours prior to going to bed doing nothing but effectively taking soap and water and trying to wash as

CERNAN (CONT'D) much of our body as we could to get free from what is really sort of a dirty feeling due to the dust. Even with soap and water it was sometimes very difficult to get clean, and the dust would get under your fingernails and other places on your body.

Radiation dosimetry - personal radiation dosimeters - Were the PRDs worn for the entire mission? Yes, with the simple exception that after rendezvous and docking, when the LMP and CDR stowed their suits, we did not transfer the PRDs. The CDR's was in the suit PGA bag for 1 day when it was retrieved. The LMP's was in a PGA bag for 2 days when it was retrieved. Radiation survey meter - Was it activated at any time? I thought about it, but what good would it do?

Personal Hygiene - Adequacy of wipes, size and numbers - As far as I'm concerned, the wipes might just as well be thrown off the spacecraft. They are too small to do any good. I never cut open a wipe bag. Now I think the CMP may have a change of heart.

EVANS I used them all the time. Whenever I had one with a meal, I would cut one open and I'd just use it to wipe off my hands and mouth. When you dip out of a spoon-bawl, part of it gets on your fingers. So you'd lick your fingers and then wipe it off

EVANS (CONT'D) at the end of the meal. That's the only thing you could use them for.

CERNAN I think the tissues, and it turned out there were plenty although the way we were using them for a while we weren't sure, and the towels are the two most important items of personal hygiene.

In use of the potable water, both hot and cold, for personal hygiene - Yes, we used it and we used it effectively just like you'd wash with a washrag in your bathroom. We used it with soap and/or water and used two or three towels, one with soap, one with plain water to rinse, and one to dry. And it turned out that there were plenty of towels also. And that closes that.

But I'd like to make one comment about personal hygiene and eating habits and defecation and urination habits in a spacecraft like the command module. I just personally feel very strong that we have a long, long way to go to make space a convenient, comfortable, habitable area in terms of defecation devices, in terms of urination devices, and in terms of personal hygiene to keep adequately clean and feel adequately clean. I think from what I understand of Skylab that we're taken some major steps in the right direction in terms of

CERNAN (CONT'D) defecation capability, in terms of showering capability, and in terms of one other very important thing, the ability to exercise. I think if we can handle those types of living habits and learn how to handle them in Skylab, I think that one of the major modes of operations in space is going to be upgraded greatly. You do them in the command module because you have to, but because of the size or because of the facilities that you have at hand, it's a messy and sometimes a dirty and almost an unsanitary operation. But you make the best of what you can and the best certainly works. But I think Skylab is a step in the right direction. I don't know all the details of their hygiene facilities, but the thought that's going in to it I'm sure is based upon the same comments we've made here.

EVANS I'd like to make one comment on the urine busses, as we call them. First of all, the little check valve in there is ineffective to me. You may as well have an on/off valve on this thing, because the check valve creates such a back pressure *that* every time I wanted to urinate I felt like I had to force it. If there is some way to get rid of that back pressure that you have to overcome in order to urinate, it would make it a lot more pleasant operation.

SCHMITT (CONT'D) The appetite inflight versus preflight was less again except when we were testing the preflight food, when I also had a low appetite. No notable differences in the taste of food. The things I liked in preflight I also liked in space. The things I didn't like in preflight I also didn't like in space. I didn't notice any differences. I tended to start to prefer to eat the wet packs in preference to any of the other solid foods. I would strongly recommend that the wet packs be used in preference to the rehydratable. You probably will get a different opinion from the other crewmen. The juices were good. After the ones and only period of difficulty with loose bowel movements I did cut out the potassium-indicated foods. I can't say that had any effect or not, but I did not have any other loose bowel movements before the end of the flight. The first bowel movement after flight, on the Ticonderoga, was normal, the second was very loose, the third was normal, and the fourth and fifth were very loose.

The size of food portions and the meal portions - My appetite was very low the first day and gradually increased over the next 2 or 3 days. It remained essentially the same after about the third day. The most acceptable foods were the wet packs and the juices. The fruit cake was good. It was possible to eat too much or to get to the point where you didn't want any more, The chocolate was good. Of the dry crackers or cookies,

SCHMITT (CONT'D) the graham crackers were probably the most tasty. The peanut butter and jelly sandwiches were quite good.

Food preparation and consumption. Rehydration went nominally. The nominal gas was present. Food temperature - I tended to prefer the foods that were warm or hot, and the hot water was quite adequate for warm foods. We actually missed the warm foods in the LM where hot water was not available.

I did not notice a water flavor. The water was reasonably tasty. I did not notice a high chlorine tase of any kind. All of the gas content did make it a little bit uncomfortable to eat at times. Thimble packages worked pretty well. Those that were divided I tended to cut off the other end of the package, the water insertion end, and use them as a squeeze package.

Spoons worked perfectly adequate. I tended not to use the fruit in the cans because of the messiness of opening those. I think the technique that Ron worked out of opening it in or near your mouth is a good one. Puddings and this kind of thing were very good. It was only the canned fruits that I tended to avoid because they were inconvenient to use.

Food bars during the EVAs I think were good to have, although I never ate more than half of one. It wasn't because it was

SCHMITT (CONT'D) untasty. It's just because of maybe a lack of interest in eating and using that time during the EVAs. Before and after EVAs, in the LM, I ate very well. There were some things we avoided. In my case, after having corn chowder once, which stimulated a major bowel movement, although not a loose one, I did not, thereafter, eat the corn chowder. I did not eat the cocoa because I tended to feel I got a little more gas from cocoa and an aftertaste. I did not eat the sea food items, shrimp and the lobster bisque and these sort of things, because in preflight I had noticed they tended to have a long after-taste. Otherwise, I think all the other foods were certainly acceptable. Many times I did not eat potato-base foods because they were very filling.

Food waste stowage - I don't know how the germicidal tablet worked. The pouch was okay. It would have been nice to have had a little dispenser that was easier to use than the pouch. I don't know whether that would be possible to do or not. Seems to me it would - a little tube dispenser of some kind, where it came out more easily. We generally cut the corner off the pouch and squeezed them out. It was a little inconvenient, nothing major. We used the germicidal tablets in all the juice bags, the food bags and the wet packs. I did not use them in the tea and coffee.

SCHMITT (CONT'D) Undesirable odors - Undesirable odors were at a minimum except for the occasional passing of gas. I generally had almost continuous passage of gas most of which apparently was not with significant odor. Only occasionally it seemed to be objectionable to the other crewmen. I think most of that was a water gas. Upon starting to eat, there would be an increased desire to pass gas. An increased pressure in my stomach apparently was transmitted almost immediately into the bowels. After eating I would pass gas for a couple of hours.

Quantity of foods eaten on the lunar surface - I think it was high, although probably no more than half of the food that was available. It's hard to say exactly. I think that could be worked out maybe with a detailed look at the menus. To estimate the quantity would be very difficult.

Fecal container - We used a blue bag, which is not a bad way to defecate unless the stool is loose. If it's loose it's just about impossible to use. The best thing you can do is to work out some prevention of loose stools rather than trying to handle them. Loose stools is one of the major hygiene, sanitary and operational. problems that you can have on a flight. I can't emphasize that more. If it happened on a daily basis, you would eventually cut the efficiency of the crew member as much as 30 percent. I think it's important to try to understand why

SCHMITT (CONT'D) Apollo 17 was different than Apollo 16 in the delay of the problem of loose stools till about the 11th or 12th day. The CDR had no problem with loose stools. My personal opinion at this point, based on very little information other than observation in flight and thinking about levels of electrolyte intake, is that with the electrolyte quantity down from the imposed on Apollo 16 we did not reach an electrolyte saturation problem until the 11th or 12th day. When that saturation level was reached, I suspect that the electrolyte we were eating was dumped or concentrated in the intestines and tended to act pretty much as a laxative, an epsom salt type laxative, concentrating water in the stool. I think it's important that we reduce the electrolyte intake so that saturation is never reached.

Water-Chlorine taste and odor was not apparent to me except during chlorination. Iodine taste and odor was very slight, apparent in the LM water, but not of any significance to the LMP.

Physical discomfort - No physical discomfort for the LMP other than tiredness on occasion and sore muscles and the bruises under the fingernails in the case of EVA work.

Gas/water separator didn't work very effectively and I'm sure that's been discussed elsewhere.

SCHMITT (CONT'D) Intensity of thirst during mission - Never really was thirsty, even during the EVAs, although I did stop to take a drink of water occasionally. But I never drank all the water in the insuit drink bag.

Work, rest, and sleep - The difficulty in going to sleep is variable. When seconal was used, there was generally no difficulty in going to sleep. When it was not used, I guess there was a tendency to stay awake a little bit longer. On other occasions, the action of Seconal did not seem to affect the rate of going to sleep. There was a tendency a couple of nights to go to sleep and wake up fairly soon after going to sleep, within an hour. The second time it took a little longer, sometimes an hour to go back to sleep. But, I feel that the medical log reports for the LMP were valid and probably an average of 5-1/2 to 6 hours of sleep per night was good. I don't think, except for maybe one night, that I went much below that. The sleep was never continuous for more than 3 hours without waking up. I feel that 6 hours is adequate sleep for the kind of work we were doing. The programing of 8 hours is necessary in order to get 6 hours because of the periods of wakefulness and for the difficulty in getting the cabin organized and everybody to bed at the programed time. So maintaining an 8-hour sleep period is mandatory in order to obtain the

SCHMITT (CONT'D) 6 hours required to perform the mission without getting tired or getting behind the power curve with respect to sleep.

Restraints - I had the feeling that I wanted to have my head and limbs restrained in order to get a good sleep, although I did sleep at times without that restraint. My personal opinion is to make them smaller with a somewhat more feeling of restraint. When I slept in the couch, I tended to put a shoulder strap over my head and chinch it down very lightly so that I had that feeling of head restraint. Probably one of the biggest things that made sleep difficult was the loss of sensory perception of limb position in zero gravity. When they were not being moved, you lost that perception. It came back immediately upon moving them. In general, the other crewmen did not disturb my sleep. I'm not sure why I would awake when I did. It did not normally seem to be the activities or the restlessness of the other crewmen. In one or two cases, I think it was the other crewmen, but most of the time I don't think it was.

Exercise - I ran maybe a mile and a half on the afternoon of the day of launch, keeping up to the daily running program that had continued for several months prior to launch. In flight, every day except PDI day and rendezvous day the LMP did some kind of exercise. Particularly running in place against the LEB, using the arms and shoulders on the Y-Y strut of the seat

SCHMITT (CONT'D) in order to provide an artificial gravity of sorts. And that seemed to be the best way that I could find to get significant heart rates. I think the medical people should have the information on those heart rates. The heart rate that I was capable of generating before my arms got tired tended to decrease, I think, with mission duration. On the day before entry, it got back up to 120. I'm not sure how much motivation had to do with that - motivation versus deconditioning. After some isometrics under the right-hand couch for 5 to 10 minutes, then I would run in place for 5 to 7 minutes, something like that. I did not use the exerciser. I found these other methods seemed to be better for my Own personal needs.

Muscle soreness during or after flight. The only muscle soreness that I can say I recognize was the very extreme soreness post EVAs, but that had disappeared by the next morning. And that was in the hands, soreness in the hands. After the bicycle exercises on the Ticonderoga, the next morning after the first exercise my calves were sore, and they remained sore after the second exercise on the bicycle. Within 24 hours, there was no noticeable soreness in the calves.

At the conclusion of each of my running-in-place exercises, I was perspiring, not to a drippy extent but to a damp extent. Never got any real visible drops of prespiration, but I did

SCHMITT (CONT'D) feel damp, particularly around the head. After a few minutes of just floating quietly, that perspiration generally evaporated.

Oral hygiene - I brushed about every other day and had no discomfort in the mouth. I did not use the dental floss and the toothbrush was perfectly adequate. The toothpaste seemed to me to be a little less abrasive than you might desire, but it did freshen your mouth and seemed to clean the teeth adequately.

Sunglasses - I used the sunglasses most of the time to look at the Moon in particular. I wore them in the cabin during PTC when the Sun was coming in the windows, up through PDI day. After that I didn't use them in the LM except occasionally to look out the window at the lunar surface. After rendezvous I didn't find the desire as great to use the glasses. Initially, it seemed as if some of the moderate to light headaches that I had might have been the result of the sharp contrast of lighting that we were exposed to as much as it was to any kind of vestibular disorientation. So I'm not quite sure whether which was which, but the headaches did disappear by the third day. By post rendezvous, I did not feel the need even to look at the surface through the sunglasses. It was as if my eyes had started to self-compensate for the increased brightness that we were exposed to. Partly, I used my glasses because they do have a small correction for

SCHMITT (CONT'D) my astigmatism, and that did increase the resolution with which I could view the surface. Looking at the Earth and translunar coast with the sunglasses, I often did that for the correction. I used the binocular and the sunglasses and it did seem to help the resolution of viewing cloud patterns and geographic locations. When I used the sunglasses they seemed to be very adequate in terms of the level in which they reduced the brightness. As soon as I looked in the cabin to look at instruments and this sort of thing, the glasses did inhibit the observation of those instruments and the lettering on the panels, and I would push them up on my forehead for cabin work.

Unusual and unexpected visual phenomena problems experienced - Let me reference you to the description I tried to make of the sunrise color-banding in the Earth-orbit portion of the flight. We talked a lot on the tapes about the orange, yellow, and red hues to the gray in lunar orbit around the edge of Serenitatis Basin. That is also on the tapes and most of that orbital descriptive work was in the post rendezvous timeline. My solar corona sketch is in my crew notebook and I'll have to get that for reproduction. And I think the only other thing I would add is that with the sunset corona, I was able to see very strong linear streamers very close to the Sun. With the sunrise, I don't recall ever seeing strong streamers or bright streamers down close, within a solar diameter or two. But the

SCHMITT (CONT'D) most diffuse and broad streamers were quite obvious and are covered in the sketch and I think in some verbal descriptions on the tapes. I noticed no eye focus problem during rapid acceleration and deceleration. The best viewing Sun angle for viewing lunar topography was the low Suns, and the best Sun angle for seeing albedo and color differences was directly down Sun or zero-phase. Often, during the EVAs, I would have the gold visor down three-quarters to protect most of my face from the Sun. But for close-in detail I would look through the lower one-quarter, where I'd just have the clear helmet available in order to see more detail without looking directly into the Sun. When we were driving up-Sun with the Sun on the visor (having had some problems with the hard-shell visor movement), I mainly used my arms to shade the helmet or the LEVA so that I could see up-sun. And that worked fairly well.

Distance judgment versus aerial perspective - The distances and sizes I used were compensated by some early estimates of crater size based on the size of the LM and ALSEP distances and items like that, although I never did feel comfortable with the numbers I used. I was doing it on a subjective basis as a result of those early observations rather than on what the crater really looked like. The craters always seemed to look smaller than I felt I knew they were, although probably never

SCHMITT (CONT'D) by more than a factor of 2 or 3. Distances would have to be the same, or the same way through judgment of haw far away from something you are. It generally results in an underestimate. You always think you're closer than you really are.

I think the tapes cover some comments on the Earth illumination at the horizons. Briefly, right at the terminator horizon of the Earth, you get sharp shadow definition of cloud features. At the sunlit horizon from lunar distance that's a very clear definition between the black of space and the upper portion of the Earth. In Earth orbit and near Earth, you can see the gradation of that horizon caused by the atmosphere. At night around the Earth, there's a very clear horizon glow all around the Earth. Air glow, I guess you would call it. And the horns of the crescent Earth are much sharper and elongate compared to those of the crescent Moon, as if light was being defracted into the atmosphere and in extending the length of the horns of the crescent. With the setting and rising Sun around the Moon, you would get a - in the case of the setting Sun - a few reflections off of the high peaks some significant amount of time after the Sun had set. And the same would apply conversely to the rising Sun. The first indication of sunrise, in addition to the solar corona brightening, was a few bright areas

SCHMITT (CONT'D) on the peaks near the terminator that were high enough to catch the first morning rays and reflect them back around toward the spacecraft.

Eye irritation during photos - I did not notice any. Helmet visor reflections I guess have been very well covered. With the dust and scratches on the helmet, of course, you needed to shade the helmet more and more in order to see with the Sun directly on the helmet.

Medical kits certainly seemed adequate. We did run out of electrolyte and some more should be packaged, I would think, for the comparable amount of time we had, because we actually did not change sensors out according to the Flight Plan. We generally wore sensors longer than the Flight Plan required, which meant had we done it according to the Flight Plan we definitely would have run out of electrolyte early. I think it is a mistake not to have a fairly clear summary of instructions for use of each of the *drugs,* if for no other reason than the no-corn case when a drug might be required. For most of those drugs, they would essentially be of little use to us in a no-comm situation because we would not know exactly what they were for and which drugs could be taken in combination without an adverse effect.

SCHMITT (CONT'D) Housekeeping was relatively easy, in general, except for the waste management portion. Within a day, the routine of where to put things to keep track of them and how to eat and all the normal and more mundane aspects of living were fairly clearly defined in my mind and did not present any serious problem.

Shaving - I did not shave until the day before entry and after the press conference. I felt no significant discomfort from the beard during any of the time in orbit. There was a little bit of stickiness involved with wearing the chin strap but that was insignificant. I think that having a beard or not having a beard has to be purely be a personal item. It cost me about an hour to shave it off, but I think that's comparable to the amount of time it would have taken to stay clean-shaven. It was difficult to shave off. I went through about three of the double-edge blades. And although none of them were seriously degraded, it just seemed that with a new blade the whole shaving process was easier. One thing to do prior to shaving is make sure you set yourself up with a good light. I might have been able to cut 10 or 15 minutes out of the shaving if I'd had better lighting. I also recommend that, prior to using the brushless shave cream, you get a lot of hot water on a *rag* and soak your beard with it. I also washed the beard with soap and hot water before applying the brushless shave cream. In spite of the difficulty in shaving, there

SCHMITT (CONT'D) was no pulling or discomfort associated with it. It was mainly a problem of the clogging of the razor and I think the dulling of the razor but there was no pulling of the beard at all.

Dust - We'll just talk about in-cabin dust. After the first EVA, there was considerable dust in the cabin. It would be stirred up by movements of the suit and the gear that we had. Almost immediately upon removing my helmet, I started to pick up the symptoms that you might associate with hayfever symptoms. I never had runny eyes or runny nose. It was merely a stuffiness in the nose and maybe in the frontal sinuses that affected my speech and my respiration considerably. After about 2 hours within the cabin, those symptoms gradually disappeared. By morning of the next day, they were gone completely. After the second and third EVAs, although I'm sure the dust was comparable, the symptoms were not nearly as strong as after the first EVA. That was as if I either developed a mucous protection of the affected areas or had some way or another very quickly developed an immunity to the effects of the dust.

Let me mention the PRDs. The first couple of days, my PRD resided in my temporary stowage bag because I did not wear the coveralls. After the second day, I wore the coverall pants and the PRD was in the pocket of the pants. After rendezvous, the PRD inadvertently was left stowed in my suit and so it

SCHMITT (CONT'D) resided in the PGA bag for two days before I had it available to put in the coverall pocket. That PRD was in my PGA pocket during the CSM EVA.

Personal hygiene - I think the LM feces bags are superior to the CSM's in that they have a goodly quantity of tissues cut to size and are quite good. I see no reason why those couldn't be the same kind of blue bags in the CSM. Although we ended up having plenty of tissue, there was some concern initially whether we would. And I think had we had any greater problem in loose bowel movements we probably. would have had an inadequate supply of tissues. Tissues are extremely useful in all kinds of personal and cabin hygiene and there should never, if at all possible, be any concern over not having enough tissues. Particularly, if you are using the BUSSes, you tend to use a tissue every time you use the BUSS - at least one. You tend to use one during the meals, and of course a lot of them in the use of the blue bag. Potable water was used for personal hygiene. I washed several times with soap, and post rendezvous I actually washed my hair quite adequately by putting a lot of water on a towel and wetting the hair quite well. Then, just in a normal terrestrial way, I rubbed soap into it and then washed the soap out again with a couple of wet towels. The soap on board seemed to be quite good. It did a good job of

SCHMITT (CONT'D) cleaning but also was not overly sudsy and seemed to wipe off or wash off very well. It did not leave any noticeable residue that was uncomfortable.