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SPACE ADMINISTRATION

APOLLO VII TECHNICAL DEBRIEFING

Part I

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MISSION OPERATIONS BRANCH
FLIGHT CREW SUPPORT DIVISION

GROUP 4
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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
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PRE-INGRESS

REP — What was wrong with the watch?

CUNNINGHAM — My watch, when I hit the RESET button, the minute hand went "chunk", and back 3 or 4 minutes.

EISELE — Incidentally, I don't know if you want to talk about watches, but I had a watch failure - the little pin. This little pin came out a couple of times. I've got it taped now; I finally taped it in flight. It came out launch morning, and I didn't want to fool around and have them run all over to get another watch, so I took it. It's the little pin that holds the band on. It came out in flight, and I put it back and taped it.

SCHIRRA — We told them to put new pins in those. Remember that? Way back - we picked those up with new pins in for flight. Let me cover the essential things before you get hung up on the watches.

EISELE — This is an old one; it works fine.

SCHIRRA — On the sensors, my two sternal sensors were placed too high, and I should know by now where they should be placed. I got tatoo marks from

it. As a result, the fittings of the harness, the BIOMED harness I had in the past were violated, and that's why this thing came apart. To prevent it coming apart in flight, I taped it in flight, when we were in the constant wear garment and flight coveralls. Unfortunately, I wasn't thinking that much, but the stress then was applied to the connector to the amplifier, and it broke there at the signal conditioner. That's why that particular lead broke. The tape part held beautifully. That's what wiped out my sensors. Donn's broke at the same place; we don't know why it broke there, but it did break there.

EISELE The only thing I could think of possibly is that when I exercised, I'd sit in the middle seat, and I put that left belt across my stomach to keep me from flying all over the spacecraft, but I'd do it very loosely; I'm not tied down. Possibly, in the act of running the exerciser, I might have bumped against the lap belt enough to break it. I don't know whether that's what happened or not, but I do know sometimes they'd call up and say they weren't

getting some of the BIODMED. I looked, and there was a wire broken off right at the little fitting where it goes on the signal conditioner.

SCHIRRA Walt's also failed in flight, as long as we're on that subject. We don't know why. We rewired all his to make it theoretically work. Basically, it ended up the configuration I had except he used sternal leads instead of axillary leads.

EISELE I don't think he had any mechanical failure; he just quit putting out a signal.

SCHIRRA We're not sure if his conditioners failed or what; at any rate, I'd say that all three were very faulty. I suspect technique caused mine, placing the sensors. I might add in post-flight I had very little disturbance from the BIOMED sensors. Donn had some very great residuals, and Walt had bleeding residual effects from the sensors, so we're not out of the woods on that area yet.

EISELE Well, I couldn't even feel mine. It looked worse than it was - physically mottled skin spots where the things had been - but there are photos of Walt's positions. Let's go back to the suiting area again and bring up the

watch. When I put my watch on - when my watch was put on is the word, I naturally would test it. I started T and stop it, then reset it. The minute hand went minus about 2 or 3 minutes; and Mr. Slayton was there and of course saw it too. We made a fast scurry, and I felt it didn't affect our suiting time line. It was still some where I felt because I could put the watch on the trailer as far as that goes. We did get an alternate watch which did fine.

SLAYTON Those watches should have been properly checked, and that shouldn't have been delivered to the suitroom; and second, they should have all been set.

SCHIRRA They should have been synchronized with local time.

SLAYTON We synchronized them with the clock in the suit room which sure isn't calibrated about anything, and the others SYNC in with the other one.

SCHIRRA It was too late.

SLAYTON In a way, I worry although other people should be. I have always had my watch, sync'ed it, and checked it. Remember, back in the old days, we would go back into the control center

and listen to WWV. It should have been done before you ever walked in the suit room.

SCHIRRA That was a goof. Let's see. Is there anything else with suiting? I had no other problems with suiting. Donn, did you have any?

EISELE I can't recall any particular problems.

SCHIRRA I would like to say that the COMM stations in the suit room are not necessarily up to spec. We had trouble talking to each other; some time you didn't get side tone with him. I very rarely had side tone at my console in the suit room. There we were, always trying to get "do you hear me?" One of the nice things there is a plus. I had this football player's chin strap which was perfect for me for launch and the first day. It turned out at the last minute that Marshall Horton gave me a cloth one to put in my suit pocket as a backup, saying "when you have a beard," - and I knew nothing about beards - "you might want this," and it turned out I used it to come home with. The plastic cup did not work with a beard on it. My face was highly irritable with a beard; you kept catching the beard in anything, and I could wear

the cup - I had to wear the cloth underneath my chin. I would encourage crews to consider underneath the chin strap rather than across the chin with a beard.

EISELE I wore a cloth one across the chin, and it bothered me some, too. But I just put up with it because it was all I had.

SCHIRRA Once you get a beard, I would suggest under the chin strap because it really bugs you. I asked that bearded guy that ran that coffin box for us. He said it took him months to get over it. The tender skin that a beard has underneath it. The bristles, the whiskers pull.

1.0 COUNTDOWN

1.2 Prime Ingress and Status Check

1.2.1 SECS Pyro

SCHIRRA — SECS pyro is per OCP; no problem.

1.2.2 Suit Connections

SCHIRRA — Suit connections, we had no problems with that. Now, we configure — and knowing the backup crew knows what the other crews don't, the would-be lock locks unlock to optimize egress. They really can slow you down.

EISELE — However, I found that I was lashed down in there; I don't know whether you guys knew it or not, but my lock locks got pushed down anyway.

SCHIRRA — One of them does when we want to egress.

EISELE — So if we bump it. I just always just assume they are locked and check it before I start to disconnect.

SCHIRRA — It's nice if you can pop out that easily.

1.2.3 Comm Verification

COMM Verification, no problems with that. One technique we use during preflight is to use the HF loop. We can always talk to each other on HF loop. We never lose communications with

anybody if we take the other loops (meaning VHF, UHF, or S-band), and turn those to RECEIVER ONLY; then you can transmit quietly across the cockpit. There are times when you should talk; we judge the elevator together, slide wire, and this kind of stuff. You need a private loop, a perfect example of it is when we were bought off from the elevator.

EISELE The center guy can't get at his switches to change them like that. What I do is just keep my mouth shut and listen to what they are saying. I would go ahead and say it, and it goes out over the loop, but nobody else hears the rest of the conversation.

SCHIRRA He could say yes, and they would say what the heck was that about.

EISELE That's right.

SCHIRRA You don't violate the security of leaving communications since you are receiving all the time. They say - CDR checks switch to so and so; you just go click, Roger, and it doesn't put a power transit on the spacecraft. By flipping back to transmit/receive, the transit

comes to your transmitter, so there's no problem with that. I think it's a very good technique to maintain crew discipline in the cockpit

1.2.4 PGA Circuit Check

and when you need to talk with each other. PGA circuit check, something the rest of the crews may not know: we had the backup and the CMP do some checks which saves all your energy. It saves a lot of work, and it's very hard to do, particularly go get the regulators from BOTH to OFF. That's almost impossible to do when you are pressurized. John Young did an out-

1.2.5 Cabin Closeout

standing job on that. Cabin closeout, there were no discrepancies. EDS checks were a surprise to the command pilot. If he will go through that during plugs out and CDDT and that stuff, it would help.

EISELE Did we do them in the chamber?

SCHIRRA No. No, it's with the booster. What's the other check? The CDG is integrated with the count down now. There's one check -

EISELE The FRT -

SCHIRRA The FRT, that's it. The FRT, you'll see it.

1.2.6 EDS

SCHIRRA — We'd advise all command pilots to get an EDS briefing from the booster honcho to see the light sequence and how they do it because you play the abort light. For example, it's A then B; you've heard all that in the loop, but there are two bulbs in all of the lights.

You could see each light work. Certain functions are alien to us, and it's the surprise that I'm getting at. So if he does FRT, he will see it. I believe all command pilots should go over that one.

1.2.7 The RCS Check

SCHIRRA I had a waiver on that, and I said "be prepared for a no audible" because I didn't know. It was audible on all of them if you're very, very quiet. You can hear them on the ground, and in flight; you can hear them all the time because your helmet is off. Most of the time, it's off, so that was quite surprising. We didn't really know what we would hear.

1.2.8 G & C Verification

I'll take the part I had. The FDAI worked fine. GDC align we did at T minus 45 seconds, and if you check your needles on NULL early enough, you just hit GDC ALIGN any time you want it. It's going to come in because the IMU is going to stay where it was. Gimbal Drive and Trim were fine. I guess the surprise was more on the pad than it was in the flight when the G&N

flicked the gimbals around at plus or minus 2 degrees. You could feel it on the ground, but I didn't feel it in flight as much.

EISELE Well, I did, but I also noticed that when you are in tight deadband, it drives you into the deadband and the jets fire.

SCHIRRA Yes.

EISELE A computer swinging that gimbal - swings it from zero plus 2 and then to minus 2 - makes these big arcs; it makes the spacecraft move and then you can get jet firing. You get a double confirmation.

SCHIRRA Yes.

EISELE In fact, the gimbals are being driven that way.

SCHIRRA GDC Drive, no comment. I set the EMS RAI on the launch pad and left it there until I needed EMS roll ON. It stayed at 12 o'clock the whole mission until I was in position to use it. However, it worked during re-entry as it should have. The only part of the re-entry phase that the EMS worked properly, I might add. EDS power, no problem there. DELTA-V SET, we did have a problem, and I didn't talk about it prior to launch. The technique is to have the MODE switch

in STANDBY. You then rotate the selector knob from OFF to DELTA-V SET, which is a counter-clockwise motion, through DELTA-V, and as you come through DELTA-V, you stop when it reads 0.0. You then go to DELTA-V SET; it should still be 0.0. You then add whatever velocity you want to set in there. For example, in our case, it was 3000 feet per second. The first time I came across to DELTA-V SET, it was not 0.0. It was 90 000.0. So I looked at Donn, and he looked at me, and I flicked it back to OFF again; it came up again 0.0, and I went "shuuuu." We had "Go Fever."

EISELE But that was the first time we had ever seen or even heard of it.

SCHIRRA It happened during the re-entry test, which really shook me. At any rate, we got an anomaly where it flames in at 90 000. We have never seen it before; we saw it with some frequency during the flight, both in NORMAL mode and in ENTRY mode. I don't think it affects the DELTA-V at all; it's just an anomaly that is in that system. The EMS is going to require some careful scrutiny. ... I should go out to North

American and sit down with those people and explain it to them. That might be worthwhile. I do feel the piece of gear is very important to the lunar flight, and I felt sick that I didn't have it myself. I was worried about the computer for re-entry. It performed flawlessly, just beautifully on every burn, better than the G&C.

1.2.9 Launch Preparation

SCHIRRA — No problems with LCC Confirm Ready. We had a problem here, and it was resolved at the last minute, but it should have been resolved long before. The cabin should be 95 percent; however, the Cape was thinking 98. One thing about the cabin gas analyzer, I think was that it played the game as fine as we wanted it to. We stowed it before close-out, and that was a good deal. It took us 5 days to get our cabin up to over 90 percent, so no sense in waiting for that.

EISELE — We never did get to a 100.

SCHIRRA — Oh, one thing, we didn't log that, did we?

EISELE — Yes, it's all in there.

SCHIRRA — I know the numbers we did. Did we log that or did we leave the damn thing on?

EISELE — Oh, Walt says he thinks he left it on a whole day (laughter), and it still worked.

CUNNINGHAM — That is an extremely good battery.

SCHIRRA — I would suggest that you take the suit sample from the commander's suit, at suit close-out, with GSE, and then scrub off on that. That makes it a lot cleaner and it's extra weight and gear that is axiomatic. We ran humidity surveys and gas analyzer surveys, RAD surveys, and I hope they are over with.

1.2.10 Systems Prep

SCHIRRA — No problem.

1.2.11 Crew Comfort

EISELE — I got cold.

SCHIRRA — Yes, but I had warned you that you were going to get warm; and during boost, we got warm, just after we got into orbit. We were just a little warm; we did get warm a little bit.

EISELE — But in preflight, it was quite cool in the suit loop.

SCHIRRA — It was so cold that that was what probably triggered my cold off. It may very well be. It wasn't shivering cold, but I guess we were a little reluctant to tell them to change the

flow because it was fairly late, and remember those cats in 190th floor? One hundred ninety feet level, that's where they had to come to do that. We got cold fairly late in the count.

CUNNINGHAM Yes, it wasn't bad.

SLAYTON It wasn't at the press conference because there were a lot of people bugging us about - you caught cold during the dove hunt, you know. I remember when I was with you I didn't have one. I am sure the question will come up again.

SCHIRRA It really got quite cold. I guess the discomfort was considerable.

1.2.12 Crew Station Controls and Displays

SCHIRRA No problems.

1.2.13 Distinction of Sounds Countdown to Lift Off

SCHIRRA Man, oh man, was that a Mother. I am going to use the word "Mother" and quote me on it, but when it lights off, there is no way you know when you have lift-off. It's just a thundering herd down there. If I had a hold-kill on that thing, it probably would have taken 10 seconds to make my mind up that I had one. When I heard ignition, it developed a real violent, shaking sound; it's very unreal. At lift-off,

I could barely see the darn clock. Countdown to lift-off.

1.2.14 Vehicle Sway Prior to Ignition

SCHIRRA Are you talking about the last 3 minutes when things are going automatic?

EISELE You can tell things are happening. I don't know exactly what's happening. You don't know what the sequence is, but you can tell, feel, and hear, at very low levels some fluids running around; and you can hear the engines thumping and feel the whole stack shake a little, and you know something is going on down there. You can't tell exactly what it is. It's very evident that the vehicle sways.

SCHIRRA It sure was vibrating up a storm. Low frequency massive amplitudes is the way it felt. That's overstated, but there was no doubt in your mind that you were being shook. I thought the world was coming to an end.

EISELE We could see the vehicle sway; at least, I could. I could look out and watch the white room structure go back-and-forth.

SCHIRRA No, you're talking about lifting.

CUNNINGHAM No, this is prior to ignition.

SCHIRRA Well, there was motion.

CUNNINGHAM You could see it. I moved a foot or two either side.

SLAYTON What do you think that Saturn V is going to sound like?

CUNNINGHAM Oh, golly.

SLAYTON That was pretty good wind.

SCHIRRA All I've got to say is that those poor cats are going to have to be hanging on for at least the first 10 seconds. I heard "clear tower," though. I heard that come up.

SLAYTON You heard that?

CUNNINGHAM I thought, "thank God, I passed that one."

2.0 POWERED FLIGHT

2.1 S-IB Ignition

SCHIRRA Okay. I think we described the ignition. The

2.2 Lift-Off

lift-off - all those words should be used: vibrations, sensations, isolations and instrumentation. The time I had lift-off, and when I had it, I couldn't hear.

SLAYTON You didn't hear Stu calling?

SCHIRRA No. At least, I don't recall hearing him.

EISELE I think I remember hearing Stu say lift-off. The light came on, and then somebody said so.

SCHIRRA Well, I said lift-off.

EISELE Well, maybe you did. I heard somebody say lift-off.

SCHIRRA Well, whatever, it's hard for you to tell if you heard Stu or me say it.

EISELE Yes, maybe I don't recall hearing Stu. It seems like I said it first. Stu said he wasn't going to say it until he was positive, and that's fine with me. Then the clock started. At lift-off, the very heavy vibrations stopped.

CUNNINGHAM Yes, you could feel the change in the vibrations at lift-off.

SCHIRRA When you left the hold downs, then the vibrations simmered down a little bit, considerably so. That might have been my detection at lift-off.

CUNNINGHAM Well, that's kind of what I felt, too, because when I got to thinking about it afterwards, I knew when we lifted off. And how did I know? I couldn't feel any acceleration or motion, and I think it was just the change in the vibration spectrum that you could feel from this kind of heavy carrying on; then all of a sudden, it dropped off. It didn't go to nothing; you could still feel something, but it was a pronounced change.

SCHIRRA It was a change.

2.3 L/V Lights

CUNNINGHAM At that time, the lift-off light came on, and the clock started. So I kind of figured that's what lift-off cue was for me.

SCHIRRA It wasn't enough to cue me, because I didn't have the whole feel. I knew I didn't because those other things kept adding up. Then things started unwinding very fast. I knew that was

the whole cue:

2.4 Roll Program
2.5 Pitch Program
2.6 Roll Complete
2.7 Rate Change

roll program, nominal pitch program, roll complete. The rate change, I don't know what that is. Is that the rate change that everybody has in their checklist that I don't have?

EISELE — That's the one you don't recognize.

SCHIRRA — I didn't recognize the 3 degrees per second versus 5 degrees.

2.8 Effect at Mach 1 Transient

Mach I - I was really worried about this, Mr. Slayton. I was worried about the fact that we could talk to each other with the COMM carriers on. I mean that the DB attenuation was very low, and yet this wasn't as noisy as the Atlas, Agena, or Titan. I was quite surprised.

SLAYTON — Was that Mach 1?

2.9 Max Q

SCHIRRA — Well, the noise was at max Q and Mach 1.

EISELE — I know it was, and I expected far worse.

CUNNINGHAM — I figured we wouldn't be able to hear each other or anything. I heard 1-Bravo!

EISELE — That's right.

CUNNINGHAM — I don't hear that in the simulator most of the time.

EISELE It was a rumble and kind of muffled.

SCHIRRA The most noise we had was the cabin venting which everybody is going to hear. You learn to hear that in the altitude chamber.

EISELE Incidentally, that's a very welcome sound.

SCHIRRA Schumm!

EISELE After about 50 seconds or so when you're expecting rumble, rumble.

SCHIRRA You figure you're going to dump and even have the lock off, and that's the point. On boost, I had the position for the two cabin vent valves in LOCK OFF so I could flick it into DUMP. Then I knew I was safe; I've got a closed loop suit circuit. If I dumped the cabin inadvertently, that's fine. Then I took the lock off, and I put the lock on when I got in orbit so I can't come into dump again without being at a low altitude or dumping because I want to. I think that's a good technique, for that reason in particular.

2.10 EDS Manual

CUNNINGHAM The EDS MANUAL. I got out of sequence as I was going to turn it off instead of turn it on for the RCS propellants.

EISELE — Wally banged my hand away and I said "oops." That was a very good hand.

SCHIRRA — Yes, I remember, - think nothing dangerous there.

EISELE — That's why I formed a habit in that regard on those both time shared checkers. We both checked each other, and we did it on a simulator; one or the other would start to do something, start the wrong way or forget to do it when you should, and we've always just kind of overlapped each other that way, so I'm glad you did.

SCHIRRA — He watches me like a hawk when I play control modes, which is fine, and it helps. I think I prefer that technique to "some where," and I've heard Dave Scott and Milby were where they will cross over each other. I think that's very bad form, but this is the way two aviators or pilots work. You learn to work together in a pilot/co-pilot relationship, and I think Donn and I've spent enough time on these systems together where we could overlap, and that was good.

EISELE — Yes.

2.11 GO/NO-GO for Staging

CUNNINGHAM — GO/NO-GO for staging is no strain; inboard cut

2.12 Inboard Cut-Off — off right on time. As called out, outboard cut

2.13 Outboard Cut-Off
2.14 S-IB/S-IVB Sep

off. Sep, boy, was that a thrill! Every time we hit an event like this where there is a pyro or something, it's a crash.

EISELE — Hark to the cannon's roar. That's what it sounds like.

CUNNINGHAM — Conditions for explosions, including this landing ...

EISELE — It always builds up on us.

CUNNINGHAM — It sounds like asking what gun is it today. Is it the 5 inch, or 38's that make a crack like that? It's more than a rifle, by far. It is really a loud noise, but it's a sharp sound. You'd think the whole back end blew off, which it did, of course, after fire.

2.15 S-IVB Engine Ignition

SCHIRRA — However, the ignition was as soft as a powder puff. I didn't even know it happened, except the light went off. The light was on, then went out.

EISELE — Well, you could feel the g's coming.

SCHIRRA — Yes, but there was no big deal. That was why we were really shocked when we got that first SPS light off. Pow!

CUNNINGHAM That J2 comes up pretty smooth; it must have a very long thrust rise because we didn't feel any sharp change.

SCHIRRA I hope that the flight quality notes a lot of g, in that, it sure felt like we got kicked.

2.16 S-IVB Plume

The SPS, that's where we need a soft light. I didn't see any S-IVB plume. I was playing EDS in rates and that sort of stuff and starting gimbal motors. I did see the big fire, and Donn could probably describe it better than I. I saw it even where I was in the cockpit. We launched cockpit bright IFR, and I saw lots of fire come by us from the retro rockets from the first stage.

CUNNINGHAM You could see those very good.

SCHIRRA I'm sure he had a real good view of them.

EISELE Yes, you could see kind of a sheet of flame come by the hatch.

SCHIRRA Yes, real big flames.

SLAYTON Looks like a catastrophe on TV.

SCHIRRA Yes, well, that's what triggered me off when I said I caught a movie on that. Okay. Let's stand by for that. I kept telling about it as if we were at launch. The S-IVB plume, I don't

recall anything like that unless that's what you were talking about here.

EISELE — No, we couldn't. At least, I never saw anything out the window on the plume for that.

SCHIRRA — Okay.

2.17 Scale Change

SCHIRRA — Scale Change. What I do after we're on the S-IVB is I go for 1 degree per second rather than the called out 10 degrees per second. Glynn Lunney and I worked this out together. I had the idea, and I showed it to him one day. Here's my logic, and I'd like to get this one across. It's wrong to do it the way the OCP, the AOH, and everything else says. Our checklist may even still have it for all I know, but it was very late that I did this. But I go to 1 degree per second, and I can see guidance initiate which is very small; it's less than a degree per second rate. Then I go to 1 degree per second. If it gets bad, I'm at 1 g or less at this point. I can go to 5 degrees per second right down to 10 degrees per second. Just go click, click. We had a simulation where I had to do that, and I went right on down to my abory rules. I think

that's the spot where they flagged us. At 1 degree per second, if something develops to make us aware that something is going wrong, you can detect guidance in initiate; you can detect the POO shift; in our case it was 734. You can actually see a little bit rate change. It is significant to see that, then have it masked in this large scale. So I would suggest that scale change should read 1 degree per second rather than the other, and I think if the guys play it that way, they'll see my point. By the way, Mr. Slayton, to orient to the next booster, we know the I-B's history.

SLAYTON Yes.

2.18 Distinction of Sounds

SCHIRRA Judging by the distinction of sounds, I would say everything that happened we heard. Wouldn't you?

EISELE Yes, I believe that.

SCHIRRA Thrusters, separations, all of that was heard.

2.19 Trajectory GO/NO-GO

Okay. Trajectories GO/NO-GO is the one we did not get a mode 4 call-out, and that really

suprised me because we always had a mode 4 call-out.

EISELE — I didn't worry about it because we'd been given an onboard guidance GO. In other words, I knew the computer was good, and I had the little card up there with the velocities versus H-dot. We were coming right up the slot, right up the groove, and as soon as we got that crossed in the mode 4 region in the chart, I just assumed that we were there, but it would have been nice to have somebody call up and tell us we were.

SLAYTON — You and I weren't on that loop, unfortunates!

EISELE — It's in there; it's in the flight plan and checklist.

SCHIRRA — Yes, well, every time we've had a launch with Houston, we had a mode 4 call-out, and quite often, I'd hammer because he didn't come up with it. They got a little gitchy about giving us GO/NO-GO's or actually modes 4, but it's very important. Watch though, on the next family of boosters, you've got an S-IVB launch to abort to orbit case, and it's going to be a lot earlier than ours.

2.20 LET and BPC Jettison

SCHIRRA Okay. The tower and the boost protector cover was very obvious to us, another noisy event, and I saw it go; a big ice cream cone just going out there and throwing off. And that event, I think, is what put a little bit of smoke on the number 2 and number 4 windows just about half an inch on the edges, as I described in the flight. That was there the whole flight.

REP Did you see that early in flight?

EISELE The smoke?

SCHIRRA Yes.

EISELE Where, down at the bottom?

SCHIRRA No, no, it was up at the upper side there where I was sitting.

EISELE Yes, well, along the edge.

SCHIRRA Yes, along the edge - the biased edge along side of us, the 45 degree angle.

EISELE Yes, you know, I didn't see a thing from that except a few particles of orange -

SCHIRRA Yes, they're the only window that we could get it because they were in the plane at the thrust.

EISELE I guess you could see it go away.

2.21 Guidance - Initiate

SCHIRRA Yes, I saw it. Guidance initiate, I made that point again on the 1 degree per second; I think it's very significant that you catch it there.

EISELE That looked to me very much like the simulation we've seen, didn't it?

SCHIRRA It was exactly the same as the simulations.

EISELE It went off about the same CMS rates.

SCHIRRA The CMS rates were good.

EISELE It came back in.

SCHIRRA It's so good that EMS velocity entry is exactly the way it worked with us.

END OF TAPE

3.1.8 CSM Systems Checkout

CUNNINGHAM Yes, I'm in orbit. It's covering the first six REV's to get a GO/NO-GO for 17 01. Okay. This was done in various steps without really intending it necessarily to be that way. That's because we have certain items on the insertion checklist and in running through the insertion checklist and looking back at it, I guess I can say that everything was nominal as expected. All the items were performed, and I'm only going to mention things which seemed to be different or surprises. We did the insertion checklist; we added an item to it which was not originally on our insertion checklist but should have been. That is the hatch gear boxes to NEUTRAL. We turned the hatch handle gear box to NEUTRAL and the hatch release itself to NEUTRAL and left the shear pin actuated, of course. At that same time, we took the bottle that was then on the line - the nitrogen bottle for opening the hatch - and we had had it pressurized with the handle in the OPEN position so that the bottle itself would all run out through the lines had we needed it on the pad. At this time, we

returned that bottle handle to NEUTRAL. The pressure was up to what it had been at boost at that time, and we noticed very late in the flight it had degraded down to about half of that. We did the caution warning systems check-out, SCS attitude reference and comparison check, Wally performed, and the two reference systems compared very favorably. I don't know if we have the numbers logged, or if we put it on tape at that point. Performed a service module RCS monitoring check which merely meant verifying the readings we had expected and they were, command module RCS monitoring checks, they were. We ran through all the EPS systems. Everything was nominal. ECS periodic verification tests consisted once more of just verifying the meter readings. Everything was what we expected. SPS monitoring check was fine. We started off the flight with the helium pressure at 30, 400 and 2500 in each of the nitrogen bottles, and I probably have in my notes some place what it went to toward the end of the flight. We next ran through the ECS post insertion configuration. No big surprises

there. We ran the post insertion checklist right down to and including the item of verifying the accumulator primary and secondary quantities between 30 and 70 percent. At that point, we held because we were in the couches and the follow-on items would require Donn getting out of the couch. The first time we flowed the radiators, we went to glycol to radiator primary valve, we pulled to bypass, and we let it sit there. Inside of 3 or 4 minutes, we could see that the RAD OUT temperature was coming down, and we did not have to recheck this item. The RAD OUTs came down under the RAD IN, and the radiator flow was complete. When we did get a GO past 2-1, Donn got out of the couch and completed the rest of the ECS post insertion checklist. We did notice a mislabeled valve in the checklist. The waste stowage vent valve was supposed to be closed. We verified that. When we got down to the optics dust cover jettison procedure, I recall that Donn had some surprises. The telescope apparently - the telescope dust cover came off very quickly, and I guess for the sextant, he

had to rotate quite a way around, at least farther than he had expected to before it finally came off. And it did come off; it came off nice and clear, and he was quite impressed with the sudden view he had out through the optics. The next three configurations we did were after S-IVB SEP, which everything went as normal. Nothing to report, just as the checklist and flight plan called out. Prior to getting a GO for 17-1, we had to perform ECS redundancy component check, and that's about the only item left to comment on as far as the systems for the first six revs. The redundant component check itself was done in it's entirety as per the checklist. Later on, we made certain modifications to the redundant component check. I might say that this was the only time that we flowed the secondary radiators with the exception of the secondary coolant loop test much later in the flight. It appeared to be working normally. I flipped the secondary heaters on and off, and I did get a transient each time even though we were above the 40 degree heater temperature. I interpreted this to

mean that as I turned them on they temporarily flashed on, but the signal then turned the heater off because it was above the threshold. I'm not sure if this is correct or accurate, but at any rate, I felt like we definitely knew that the heaters did come on and off because I did get transient at the time I threw the switch. At this time, the checklist called for the evaporator water control secondary valve OFF; I believe we turned it off at this time. The first time the primary evaporator dried out, we turned that evaporator water control secondary valve to AUTO, and it remained at AUTO throughout the rest of the flight. Primary coolant loop deactivation was done per the checklist whenever it called for, and secondary coolant loop activation was done per the checklist whenever called for. At this time, during the redundancy component check, I did notice that the glycol accumulator quantities were running towards the low end of the acceptable range, and I made a mental note to keep an eye on it. However, it never really changed throughout the flight. I wasn't concerned that it was

low since all indications were that it was not changing much in volume because of temperature effects at all.

3.1.9 SXT Calibration Test

REP We probably ought to make it clear that we've got an area in here that we've missed, in case someone is looking for that, and that will be coming up later. From guidance it goes through the sextant calibration tests. See?

REP Yes.

EISELE Well, the first surprise I got on the optics was when I went to get it from the optics cover. I was told that 20 degrees of shaft rotation would kick the covers off, and it took about 180 degrees before they let go. I had my heart in my mouth there for a few seconds until they finally went, because I could envision the thing not coming off and us having to do the whole rest of the mission with nothing but COAS alignment which we also hadn't verified at that time. However, they did pop off, and I could see the little pieces with sunlight reflected off them disappearing as they drifted away from the spacecraft. Now the sextant calibration test I did using, I believe, it was Canopus and Regor. There were two stars in the southern hemisphere, and it just happened that this piece

of sky that I ended up looking at for the test only had two Apollo stars in it, so I was not able to use a third star. But I did do the test for DTO, put the fixed line of sight on Canopus, and used the movable line of sight to bring, I believe it was Regor, into the super position. Then I made a mark, and I gather that was sufficient for the test because no one ever called up later on to ask for it to be done again. The optics quality, in general, in the telescope, is not too good. It's about like the simulator; in fact, it is not quite as good as the simulator. You have to get dark adapted to use it, and that was another real shock. I put my eyeball on the telescope and didn't see a blooming thing for about 4 or 5 minutes. I got dark adapted and finally the brighter stars came first, of course, and then finally the dim ones came in. A great many of the dimmer stars that make up constellation patterns are very difficult to see; you don't see them right off. You can look in there, and you may see a handful of very bright stars, well known ones, ones that you would normally recognize from their constellation

patterns, but you have to look at it for a long time before those dimmer ones come in and fill out. For instance, Taurus, you can see Aldebaran pretty early. That's a nice bright star, but the other stars that make the V in Taurus don't show up right away. But if you just keep your eye on it long enough, for 5 or 10 minutes, you can see all of them that you need. The outer fringes of the telescope are distorted and blurred, and it is very difficult to recognize constellations when they are out on the edges of field of view. Of course, the field of view is movable, and you can take your optics switch and drive out there and put that part of your field of view in the center of the scope, and, you know, verify that whatever you thought it was really is the right star, or verify that it isn't in some cases. You can get faked out once in a while. Mechanically, the telescope and sextant drive very smoothly in both direct and resolve and in all speeds. The manual aspect of tracking stars or landmarks or whatever is a very simple task to do, and you could get more than adequate training on that in the simulator.

I would suggest for other crews that, after you have gotten your initial orientation on the celestial sphere in this planetarium, that you forget all about planetariums and stick to the simulator. It is a very faithful reproduction of what you are going to see in orbit with regard to the stars.

REP Stars that you can see in the sextant? With the sextant I don't guess you had any problem?

EISELE No, the sextant field of view, again, is very much like the simulator except that they do not simulate all the other dim stars that you'll see when you look through the real one. I didn't have any trouble any time recognizing the one that I was supposed to mark on because the Apollo stars are all bright enough, in relation to the little ones around them, that you don't have any trouble picking out the right one. And you can just pull it in there and hit the MARK button. One little, kind of irritating thing is that you have to adjust the radical brightness when you go from sextant to telescope and back again, so you are continually rolling that thumb wheel up and down to get the right brightness

setting. But you learn all these little things after a few times, and it's not a big deal.

3.1.1C COAS Calibration

EISELE The COAS calibration worked out very well. I thought that it was a much easier task to do in orbit than it is in the simulator for two reasons. One is that the light loss through the COAS didn't seem to be quite as bad in orbit as it was in the simulator. Again, that's kind of a subjective thing, but I had the feeling that I could actually see stars better through the COAS in orbit than I could over here. Also, the simulator is a little jerky; when you put in a pulse it doesn't always take. In orbit it always does, and you can track that star very smoothly right through the center of that radical pattern, and you can't, you never freeze it. You can't ever stop motion - altogether, but you can get the rate such that the star will track very slowly right through the center, and when it gets to the center, you just hit the ENTER button, or whichever one it is you use to mark - the ENTER button. You get a sextant calibration that way, and it worked out very

well. I found that the angles were about a degree off in shaft and trunnion from where they were supposed to be - that is according to you know, where you expect the X-axis of the spacecraft to be, and we did another one later on in the flight. Wally did one, and I think they were still within about a tenth of a degree of that original reading, so the business of removing the COAS and then reinstalling it doesn't seem to change the orientation of the thing very much. It's very repeatable. I thought it was a very simple task to perform, and later on our results of using the COAS for alignments were quite satisfactory in rendezvous. IMU orientation and alignment -

3.1.11 S-IVB Ventilation

REP — Do you want to agree with that - any of the ventilation in these ice clouds of vapor, or - just leave that for -

EISELE — Oh - I don't know what that's all about; I didn't ever notice any ventilation or ice clouds or vapor around the S-IVB.

REP — These are some of the questions that they - they sent from Marshall out here.

REP Why don't you just make a negative response and say I didn't see anything.

EISELE You might ask Walt and Wally when they get back, because they had a better view of it actually than I did. I just caught a glimpse of it now and then out the hatch window, and once in a while I could peak out the others.

REP I believe Wally said he thought he could see a little bit there once, little streamer, but not of any significance.

3.2 Rendezvous

3.2.1 IMU Orientation and Alignment

EISELE Well, IMU orientations and alignments we did per checklist, before each of the burns. And I tried, at least particularly in the early part of the flight, to get a leg up on these alignments and not wait until just two revs before the burn. I even started three or four revs before on this one because I wanted to be darned sure that I had a good alignment. Of course, at this time, for these two SPS burns, we had had the IMU up continuously since lift off. So we had an orientation, and we could use AUTO optics and everything to tweek it in, and it worked out

very satisfactorily. We did the, I think it was a nominal option 2, for the burns to bring it into some local vertical alignment at a particular time which is aimed to be TPI time. And I didn't have any particular problem using the computer or the optics for these alignments once I got used to the idea that the light transmission in the telescope wasn't as good as I hoped.

3.2.2 AUTO Maneuver-To-Burn Attitude

EISELE On the maneuver-to-burn attitude, we didn't do much of an AUTO maneuver-to-burn attitude. What we usually did, or what we always did, was fly the thing manually to within a few degrees, and then put it in, say, wide deadband and SCS. Then as we finally got down to within a few minutes of the burn, say 10 to 20 minutes, you would tweek it in very tightly and then go to narrow deadband and then throw it to CMC AUTO and let the computer hold it. So about the only AUTO maneuvering we really did was the trim maneuver that we do just before the burn. We have a flashing 15-19 on the computer, and you hit the ENTER button, and the computer will then disauto-pilot within tweek of the spacecraft right into

the attitude. And so that's all we did, and the reason we didn't is that we found on the simulation if you have a large maneuver to perform the computer has a strong preference for maneuvering in yaw rather than pitch, and it'll drive you right through the gimbal lock region some times. So we just flew in flight like we trained and seemed to work out okay.

3.2.3 SPS Burn 1

EISELE

I am sure the other guys will have some comments on these burns too. As far as subjective impressions, particularly that first burn, we didn't know quite what to expect, but we got more than we expected. That thing really comes up in a hurry, and it's a real boot in the ass when it lights off; it's not a smooth thrust rise like you get off the larger booster engines. Man, it comes on all at once, and smacks you right in the tail, and just plasters you to the seat. It's pretty close to one g, and man, things are really going fast, and those numbers are clicking down on those counters, and valves are opening, and you watch the gimbal needles go up and down, and it's a real thrill the first time

particularly, to see it came out smooth as glass. We had some small residuals which Wally burned out very easily with the RCS system right after the burn.

SLAYTON Is the shutdown as abrupt as the start, too?

EISELE Yes.

SLAYTON Clean shutdown.

EISELE It sure is. Bang, it's ON; and bang, it's OFF; it's very abrupt. Then we had a - I think I did the alignment between the burns. We did not have to do that intermediate MCC burn that they were talking about because the MCC-1 first burn was right on the money and came around; and I think I got an alignment in just before NSR there, but the tape will show it. It was just a P52 fine align. I had noticed by this time that these gyro torquing angles were very small, even though the IMU had not been fine align for a period of several hours when you did it; the gyro torquing angles were way down in the hundredths of degrees in most cases. So I felt pretty good about the IMU; and, apparently, it was not even drifting anywhere near the allowed spec values.

3.2.4 SPS Burn 2

EISELE SPS burn 2 was very similar to burn 1, the same sort of sensations; and it, too, was apparently right on the money. The targeting

we got from the ground was just about letter perfect. Wally burned out the residuals to about one tenth of a foot per second with the RCS, and from then on, we were on our way. I wonder if I could just go through this in narrative rather than follow the exact check-list because -

REP Whatever makes sense to you.

EISELE Why don't you turn off the tape a minute? I want to get my book. After the first SPS burn, I did a little P20 tracking exercise, and I didn't actually do any MARK's, but I did ask Wally to maneuver in pitch to the point where I could get the S-IVB in the telescope field-of-view, called a P20, and found that the thing did in fact track the target, that I could see it in the sextant but not in the telescope; and I believe at this time, we were in daylight so that the S-IVB was visible with reflected light. It came in loud and clear, and I did that mainly as a confidence factor, just to be sure I could see the thing; it worked out pretty nice. After NSR, we called up P20 again, and I found that after the initial

transients in attitude control and optics line-of-sight control that the computer settled down and tracked the target quite smoothly in auto optics. In the simulator, we had had some trouble with the thing being pretty jerky, and also in attitude control there were quite a lot of jets. After I made a few marks, the thing really settled in, and we had hardly any attitude maneuvers. Once in a great while, it would decide that it needed to correct its attitude, and all of a sudden, it would take off and move about 5 degrees and man, you'd think the thing was going wild, but if you just sat there and waited it out, it would settle back down and track the booster. There is a way of getting around that. You can actually do it manually if you want to, but procedurally it's much simpler just to let the computer track the thing and not worry about trying to fake it out. It doesn't use up that much fuel. The DELTA dot-R and DELTA-V updates were very small throughout the pre-TPI phase.

3.2.5 TPI Burn (RCS)

EISELE

One thing that was disconcerting was that when I recycled program 34 to get another TPI solution, the darned thing would quit tracking in auto optics. In fact, it didn't just stop it; it would just take the sextant and drive it completely off target somewhere, and since I could not yet see it in the telescope, I was sitting there flying blind as far as keeping the target in sight until it finally quit calculating its solution, and then it would pull the target back in. Also, another surprise was that the TPI solutions took about 4 minutes, 4 to 5 minutes, whereas in the simulator I timed it, and I think the longest one I've even seen was about 3 minutes over there. So I elected to change our procedure slightly in that rather than waiting until TPI minus 5 minutes to get the final solution, I went ahead and took it around TPI minus 14 minutes to get all that done so it wouldn't interfere with our backup MARK's at 8 and 5 minutes. At about TPI minus 9 or 10 minutes I believe it was, I took another VERB 85 plot

(that's line-of-sight angle from the horizon to the target), and our procedure is that when you get the target centered in the sextant, you punch the VERB button and that freezes the display; then whoever is taking plots can write it down and get the data. I goofed and forgot to hit key RELEASE, so that when it got to 8 minutes, it was still locked up on the reading; it had been there 2 minutes ago. So I hit the key release, and we did a reading; I think it was about 30 seconds late. Just about then, for some reason - I'll never know why it did this - but for some reason, the computers - the optics drive started jumping around, and it finally went completely off the target, and I lost it, and it never would come back. This was about 7 minutes to TPI. We scratched our heads for a while, and I compared the ground's solution with the computer's TPI solution and decided that it was close enough to go ahead and burn it on the computer because after I looked for the star - rather, for the target for a few minutes, and it wasn't there, I finally gave up on it, went on into P41 where

you do get the DELTA-V components and local vertical coordinates, compared those to the ground, and they were right on the money. So I said, "well, the only thing we can do is go ahead and try the burn and burn what the computer said," and that's exactly what we did. We even did an auto maneuver to the burn attitude. We were bellied up to at first - bellied up to the first, bellied up with the optics line-of-sight looking at it and went ahead and did an auto maneuver and just let the computer fly it back down to the burn attitude; it just tracked in nice as you please, just did a pitch maneuver, and the only thing I didn't like about it was the out-of-planes solution. We had about 10 degrees out-of-plane, and I felt that was too big, and I can't tell you why. It's just a Kentucky windage that we kind of picked up after running in the simulator some, plus the ground solution didn't call for that much out-of-plane either, so I suggested to Wally that he take about half of that out-of-plane angle out of it, and he did that. I don't know whether that

was good or bad, but I know that we did end up coming up pretty much in plane at final breaking. So that's the way we did TPI, and Wally couldn't see it in the front window, either. Apparently, those flashing lights aren't all that bright. They just don't show up until you get within 15 miles or so. They do in the sextant, but not through the telescope or the front window. We burned it blind without having the target in view; and then after TPI we went through the procedure and got back into P20 automatic tracking again, and it brought the target right back into the sextant; then we could do some more MARK's, and we went on. At that point, the image was so large in the sextant due to magnification that it was no longer point source. It was four discrete spots of light - you know, the four lights on the SLA panels - and they were flashing alternately and intermittantly, and the booster was also tumbling. This made it a very erratic and difficult pattern to work with because you could never pick out exactly what the hell the center of it was to know where to MARK, so I

was kind of going along guessing about where the center ought to be. Apparently, it worked out because we got very good results on our DELTA-R and DELTA-V update, and we got a very good solution at first midcourse. The computer called for three and one half feet per second aft and a little bit down, and Walt got 1.7 on his charts, so I just suggested that we burn 2 feet aft. You don't like to take that energy out after you've put it in, so we just burned 2 feet per second aft, and I think just a couple of tenths down; and, apparently, it put us right on the slot because the second midcourse came up zero or less than 1 foot per second on the computer and less than 1 foot per second on the chart, so we didn't burn anything at the second midcourse; we didn't need to, and our polar plot showed us going right into the target. So that's the way the burns went. All this time, of course, these lights were flashing in the sextant, and they were - the closer they got, why of course, the more erratic the P20 tracking became, and the harder it was to make MARK's because the

target got bigger and bigger, although we were still in darkness and all you could see were these flashing lights, and it just looked like a bunch of flash bulbs popping out there. The phasing was just about perfect because we broke into daylight and could actually see the booster in reflected sunlight, I guess, when we were 2 or 3 miles out. It was just about the time when the thing began to have some finite size in the COAS through the window, and from then on we used Wally's estimate of subtended angle and booster diameter plus charts to get a hack on our range in conjunction with the display on the computer. The computer solution of range and range rate was, as near as I could tell, pretty good all the way in to the final phase of breaking and line-of-sight control.

3.2.6 Thrust Monitor (LOS Control)

EISELE The line-of-sight control — I'd better let Wally talk about that since he did most of it. As I recall, we had very little thrusting to do in the up and down, in the in-plane portion, and he did do some cross-plane thrusting, which

I think had some out-of-plane components; we tend to want to bring that out-of-plane in so that you come in right on the bellyband. I know theoretically that's not most efficient; but, in practice, that's the easiest thing to do, so he will have some comments on that. I guess that's about all I have on rendezvous. I'd like to discuss the postrendezvous tracking at 80, 160, and 320 miles. We could see the target.

REP Before you get to that, would you like to make an overall summary that we can - conclusion about the ability to do this with one man?

EISELE With one guy, it's a bitch; I'll say that. If I had two guys out there on the LM -

REP I thought that was pretty wild.

EISELE Well, I would hate to go and get somebody under these conditions. It's not so much the one-man time line, it's just that - you're never sure what the hell you got, because you don't have any radar. With one guy, particularly, you don't have time to do backup charts; you don't have time to deliberate and make these comparisons between ground and chart and your computer,

and just about all you can do would be to work the computer, take the solution, burn it, take advantage of all the auto tracking and optics and all the auto maneuvers and everything else, and hope it came out right. That's all you could do. And I believe the rendezvous solution particularly is that you get a good - a nominal initial condition from the ground, on this first burn. You could probably get away with it, but it is not the kind of thing that you would want to hang your hat on for the purpose of rescuing people.

EISELE I felt very good about it being successful, but I felt very uncomfortable when I thought about it in terms of two guys being out there in the LM. There is just no way to go without radar. I've got some numbers and stuff, but that -

REP You're talking about range range rate information.

EISELE Well, yes, without some kind of -

REP That would be VHF ranging.

EISELE Well, yes, that to me is radar, a measurement of some kind.

REP Yes.

EISELE Rather than computed in. Particularly at T-align, the tough part is the tail end of visual ranging; even though we got away with it on S-IVB, that's a big target. You've got a little dinky LM out there, and you don't have a subtended angle or a fixed reticle type of thing to really measure the optical range; you're really flying blind, I would imagine ... Oh, I might discuss the breaking schedule. We did use the computer in conjunction with Wally's estimates of booster size to get a hack on our distance and our closure rate.

EISELE Again, this is the kind of thing that you develop more by experience. We have certain gates where you're supposed to be a certain speed at a certain distance; but there is so much uncertainty as to whether you are really at these gates that it is difficult to judge. So we just developed enough coordination such that you can kind of tell by the way things are going, by what Wally says the size of the target is, and by what the DSKY is telling you that you can anticipate when you should do a certain amount of breaking. I think we did it in two or three steps, and it came out just fine. If you kill-off too soon, you don't make it; and if you wait too long, you go whistling by it, but that's pretty much by the seat of your pants. The postrendezvous tracking was kind of interesting. We found that you could, in fact, see that darn thing in the sextant at those distances. In fact, even at 320 miles, I could see it well enough to say that it was something besides just a point source, that it actually had some little bit of shape to it. Okay. The subject is DELTA-V bookkeeping for

EISELE

rendezvous. We had a DELTA-V budget called up to us of 90 feet per second; and, of course, the problem onboard was to keep track in real time of DELTA-V expended. Since the fuel readout is not that accurate, the only way we can bookkeep on RCS fuel is by keeping track of DELTA-V maneuvers. There are two ways you can use NOUN 40 on the DSKY, or you can use this display in program 47. I started using the program 47 displays where you let the counter build up; then you recycle it to zero and write down the numbers. Toward the tail end of the thrusting maneuvers, recycling became rather rapid, and it's a little hard to always get it zeroed at the right time to get the next batch, so I went to the NOUN 40. The trouble with the NOUN 40 is that it integrates every single little pulse that comes out of the PIPA's, and they kind of have a tendency to go plus and minus, and they'll average out in the average "U" routines; but they do not average out in the NOUN 40, for some reason. We took a combination of what we knew we had burned at the midcourse and the TPI plus the NOUN 40, and I think it

EISELE came out to something like 75 or 80 feet per second. I just arbitarily in my own mind, at least, took off about 15 feet or so because the NOUN 40 counted up to 50 feet per second, and I didn't think we burned that much after TPI.

CUNNINGHAM Did you cover the burns that we did put in?

EISELE Yes, I talked about the TPI burn, the midcourse.

CUNNINGHAM How about the bookkeeping?

EISELE The item of concern is the bookkeeping on the breaking log, and I got 11, 3, and 16 feet per second recorded in four and one half. I've got 14 left, about 16 right, and practically nothing up and down. The thing that puzzles me is the left and right in that if we had a large out-of-plane correction, which we might have had, you'd expect it to be mostly one way. I'm a little suspicious of my numbers. I do know that Wally did a considerable amount of inputs to null out his line-of-sight rates sideways. Whether or not our DELTA-V bookkeeping is accurate and up to date, I don't know at this time. I think we will find out when we get the high bit rate data back.

CUNNINGHAM Did you cover the TPI burn where I didn't get the high bit rate on?

EISELE No, I didn't mention that. We did not get the high bit rate on for TPI. Consequently, we will probably not know precisely how much we burned. The computer solution was something on the order of 17.3, is that the number?

CUNNINGHAM Yes.

EISELE We burned the residuals to as close to zero as we could get. Of course, they pop around a good bit.

CUNNINGHAM I think they add to about a tenth.

EISELE Also, the DELTA-V counter was pretty close to that. So I would say that if you put down a number like 17.5, you would be within a half a foot per second of what you actually did burn at TPI.

CUNNINGHAM Why don't we elaborate? Did you mention the confusion or consternation when we lost the target at TPI minus 5?

EISELE I did.

CUNNINGHAM Well, as a result of that - I have written on the top of my chart here all these things - high bit rate for all the burns when we were

CUNNINGHAM busy figuring out what we were going to do about the whole thing. We got down to deciding finally to burn the computer solution, and we were all ready at that time, and we burned, and I didn't get high bit rate on for that burn. But I had high bit rate on for the midcourse, and then we started breaking. I had high bit rate on for the rest of the way, so it would all be on tape. All of these DELTA-V's should be on tape.

EISELE Yes, it was a little spastic there on TPI because it's a good example of how operational problems pop up on you. The first thing that happened was that we lost the target. Well, that shook me up a little bit, and we were thrashing around, trying to figure out what to do. About that time, Wally was trying to look out the window and found he was being blinded by light reflection from the floodlight. We had forgotten to put up the floodlight screen. So I went scrambling into the stowage box to retrieve the screen, and when I did, my checklist floated away somewhere, so I didn't have a checklist for a while.

CUNNINGHAM — He handed me the screen, and I sat there trying to snap the screen on, and there are two other snaps that hold the cable. We had only seen that screen about a week or 10 days before the flight. We saw it once in the simulator, so I got wrestling around with pulling snaps off and putting the screen on. About that time, everybody decided to burn the onboard computer solution that was less than 3 feet in difference, according to ground. We went ahead and burned, and about the time we were getting over it, I remembered the high bit rate. We never did get to it. I finally got the screen up, but we didn't get high bit rate.

EISELE — That 5-minute period I think was about the fastest four-handed game I ever saw.

CUNNINGHAM — Six-handed game!

3.3 Postrendezvous Through Deorbit Burn

3.3.1 S-IVB Postrendezvous Tracking at 80, 160, and 320 NM

EISELE — That's enough on rendezvous. The postrendezvous tracking went off very smoothly. We could see the target very easily up to 320 miles in the sextant. I never did see it in the telescope that far out. These were done during daylight

EISELE passes so that we had reflected light. One time, I did see it at night. I think it was either 80 or 160, and the sextant - I could actually see the lights flashing. What was kind of interesting about that was that the lights stayed on a lot longer than the 7 hours they were supposed to. This was like 10 or 12 hours after rendezvous, and they were still flashing.

CUNNINGHAM Did you cover the discrepancy between the computer solution and the backup solution at midcourse?

EISELE Yes.

CUNNINGHAM Okay.

EISELE Basically, I think we burned the chart rather than the DSKY.

CUNNINGHAM Yes, and not all the out-of-plane, not all the down.

EISELE We burned about half the down.

CUNNINGHAM Incidentally, on seeing the S-IVB visually later on that night - that night being local Cape time - Wally and I were still on watch; Donn was asleep; and we saw the S-IVB behind us. At that time, it was called out at a thousand miles.

EISELE I think that was a day later, in fact.

CUNNINGHAM Yes, it was a day later. It was very, very bright.

SCHIRRA It was in reflected light just at sumrise.

CUNNINGHAM We were already in the dark, and it was above the horizon. It was at a thousand feet and was brighter than any star out there. I can't wait to see some of those pictures.

3.3.2 SCT Star Count Test

EISELE We did the telescope star count test as per procedure, and I guess the people on the ground were happy with it because they said the star count went right in line with their predictions. The only reservation I have on this whole deal is that I don't want someone to reach the conclusion that doing daylight alignments with this rig is no sweat because, in general, that is not the case. It is very difficult to see anything useful in the telescope when there is any sort of daylight around. The sextant is different. If you already aligned properly and you do an auto optics maneuver to bring a star into the sextant field of view - you can see stars in the daylight through the sextant. You

can see it right up to a relative sun angle of maybe 40 or 50 degrees. You still see bright stars in the sextant, but that's the only thing you can do with it. If you're not aligned or if you've drifted off such that you can't get the star to come into the sextant, you're out of luck.

EISELE No, sir, except for a few minutes at sunrise, right at around sunrise or sunset. If your back end is at the sun so that you're looking out away from the sun into the dark sky, you can see stars for a few minutes either side of sunrise and sunset, but that is about the limit on daylight type realignments. I guess the application here for lunar flights is that this is the kind of situation you are going to have all the way to the moon and back where you've always got the sun out. What you're going to have to do is turn around and point the SPS engine at the sun and then hope that you're not looking at the earth through the telescope at the same time. My recommendation is that the Colossus and those other programs incorporate a feature to allow the use of the nearer bodies (the

earth, the moon, and the sun) for approximate alignments sort of a course alignment.

REP — Are you sure you know how to run this one now?

CUNNINGHAM — The subject is item 3.3, subject 3 under - on the debriefing chart, S005 and S006 photography; there are various ways of covering this. I think you could talk about the cameras. We had one flight-modified Hasselblad camera on board. Our general feeling was that we could have benefitted greatly by having two Hasselblads, for several reasons. One, in case one failed, and we did have problems with the single Hasselblad; and secondly, there were times when two people could both have been taking pictures. For example, the multispectral photography: one man could have had the green filter and another man had the red filter, and we could have done a much better job all the way down the line, but we didn't, I think, primarily because of the fact that the modified Hasselblad seemed to have problems that the unmodified commercial Hasselblads don't have. Various modifications were made which allow you, in certain instances, to pull the trigger with the slide still in, and you can't tell. On the S005/S006, I just broke it down to a couple of categories. I'm

going to tell you something about the cameras, and then about the film, and then maybe pictures. But on the cameras, to repeat myself, we felt like the modified Hasselblads brought in problems that don't exist with the commercial Hasselblads. One of these is the slider that goes in the back. The modified Hasselblad back has got a round knob that protrudes on the left hand side, and the slider, if you put it in facing one way, will go all the way down; if you put it in facing another way, it doesn't go far enough down to stop the shutter from throwing with the slider in. This is impossible with an unmodified back. Another thing that is missing off the modified back is the depth-of-field scale which can be useful in some cases for interior shots. I think on this flight, we got some very decent interior shots with the SO368. Still another one that would be nice to have, and preclude you from ever losing a frame accidently, is the little dot on the back of the camera. You still get the dot on the camera when it is cocked, but the window is removed from the back; and in a commercial

Hasselblad, when these two are the same color, white or red, you can put the thing on. It precludes you from putting a cocked one back on an uncocked camera and winding one slide through uselessly.

SCHIRRA They really goofed a good camera, Deke.

CUNNINGHAM Those are primarily the main criticisms; if something else comes up, we'll have to cover it later. The camera itself is still very, very useful for pictures. One some occasions, we used the ring sight; on others; we didn't. I think for my case, I would aim down the camera, line my eye up, and put it right down across the top of the camera, and have a good view of what I was shooting a picture of. The pictures themselves were taken with three different kinds of film, and this, too, introduced certain problems. We had S0368 on board which was to be taken with no filters; we had S0121 which was to be taken with the 2A filter. (Incidentally, the 2A filter was in no way, shape, or form marked 2A in stowage. We had to verify that with the ground.)

SCHIRRA Sight, we assume, eliminated the problem, but we still wanted to be sure.

CUNNINGHAM The Panatomic-X film was taken with a red filter and a green filter, each of which had different filter factors associated with it. Each of those three films, incidentally, had a different ASA number to be taken with. We ought to make note of the fact that all of our pictures were shot with a light meter, except the Panatomic-X film. For the Panatomic-X film, we used the gouge that was on the backs, and made an estimate of whether the sun was 30 degrees above the horizon or not and used the can solutions for exposures. We had some problems in the fact that we generally had two kinds of film out to be available when we needed it to take pictures; and changing backs obviously entailed changing filters and ASA numbers on the light meter. There were times when we lost some pictures because of either not getting a red filter off when you took the Panatomic-X back and put it on, or vice versa. We took one whole role of SO121 without the 2A filter on, primarily because we were also

taking SO368 at the same time (this was during the S-IVB turnaround and SEP maneuver and that time frame), and we did not want to be messing with the filter coming on and off. This was also labeled on the back. We also took that same roll of SO121 at an ASA of sixty-four instead of the recommended forty-five to fifty, which we did on all the rest of the backs. That was to preclude having to reset the light meter. There were a very few frames, maybe two or three throughout the flight, that were lost because of refocusing the camera from 3 feet to infinity.

SCHIRRA That's a high risk.

CUNNINGHAM That is; that's a high risk. It's a procedural type error, but it is something that you can very easily get suckered into when you are changing backs, ASA numbers, filter factors, and focus distances on the camera at the same time.

SCHIRRA I wasn't listening completely, but I would like to add a point.

CUNNINGHAM Go ahead.

SCHIRRA — The Hasselblad as a designed camera is a good foolproof camera.

CUNNINGHAM — I didn't cover that item by item.

SCHIRRA — We've made it for idiots, now, and I think it's wrong because it is not idiot-proof, now; it's too simple.

CUNNINGHAM — You might repeat your comment about your own Hasselblad.

SCHIRRA — I never have goofed with a picture with my own Hasselblad. I've missed a picture because the slider was in; that's much better than blowing a whole bunch of them with the slide in. I've never goofed on shutter setting; I've never goofed on focus because I have reflex action; and there is no reason not to have reflex action; there's lots of room in there.

CUNNINGHAM — You could also use the little eyepiece.

SCHIRRA — There is a reflex eyepiece, so you don't have to look over the top (you see photographers using that), and I would recommend rather than have it close up — because then, inside the cockpit with it, you know, it has to be set at 3 feet, the guy's out of focus — you look out the window, and it has to be in.

CUNNINGHAM We feel that we have room in this spacecraft to get up to the windows like that.

SCHIRRA Lots of room - fantastic room.

CUNNINGHAM I think every one of us, at least once, took pictures with the slide in - attempted to, I should say.

SCHIRRA You could see a filter on there if you had it on. For S0368 I blew two of those.

CUNNINGHAM Stop it a minute. I don't think we can -

SCHIRRA I recommend - we haven't really brought this up till right now — that we get this forward looking —

CUNNINGHAM It's called a prism viewfinder.

SCHIRRA Yes, that's a stock Hasselblad item for precise photography of the LM, of lunar landmarks, of earth landmarks. You can look right through it; you can tell then whether you have the window cutting out your picture or not, as well; and it's real good.

CUNNINGHAM Also, you don't get a ring sight then if you look right through the lens.

SCHIRRA We lost the right sight one time, and all of a sudden, it came cruising by - "Ah, there it is."

CUNNINGHAM Getting back to the films -

SCHIRRA You said one other thing; I'd like to correct you. Walt is not a fan of the ring sight; I am. I would rather correct it. That's an opinion. I feel the ring sight is required for a precise picture of a precise area.

CUNNINGHAM We did use it sometimes.

SCHIRRA Yes, I know, but you inferred that it wasn't a requirement; I think it is.

CUNNINGHAM I don't mean to imply that you shouldn't fly the ring sight because I used it lots of times. For example, I used it on the S-IVB picture; I used it in cases where I felt that I had to be more precise, where I had a narrower field to take a picture of -

SCHIRRA If you were going over the Cape and you wanted the Cape and not just Florida in general, you would know that you could get Florida in general, but to get the Cape in the middle of the picture, you would have to use the ring sight.

CUNNINGHAM Yes. There's one other thing to add to this. In my training with the Hasselblad over the last couple of years down here for example, I did it both with and without the ring sight, and I concentrated when I didn't have the ring

sight, I'd take a whole roll of pictures and come back and find out that I was aiming the camera always a little low. I corrected it to the point that when I took my pictures without a ring sight, I was being able to center the thing pretty good. Now that's merely a personal preference, and I think the ring sight is a good thing to have; I really do. I would never recommend that you don't have the ring sight along.

SCHIRRA I would dispense with the ring sight and go through the prism reflex. The real reason there is that you are always worried about spacecraft structure knocking out some of your picture, and with this, you don't. You know what you're looking at.

CUNNINGHAM Yes, I definitely felt that, too. When we have taken the 16mm pictures, you got the camera sitting up there, and it's trying to look down the X-axis, and you always have a little bit of a problem with that camera getting a little -

SCHIRRA One of my problems on that stripping: I guess I was the one who really got the multispectral stripping, and it turned out that way because he

unfortunately had the slider in. When we came across South America, we had a long strip of this with the red filter on, and the object was to overlap, so I stripped with the Hasselblad, and I couldn't remember every time what I was looking at. With the sighting on the top of the camera trying to pick the same target and move the target enough so I would overlap it, there's a lot of pictures. If you could look through the lens, you would know that you weren't goofing it.

CUNNINGHAM Yes, I agree.

SCHIRRA This is going to be true with that four-camera system in the event you should have a sight like a tube sight, not just a little ring sight.

CUNNINGHAM On the various kinds of film on board, I don't think we can overstate the fact that pairing mixed-up film loads does create operational problems. We always run the risk of having the kind of interchanges of filters and filter factors, ASA numbers and backs, and it's not insurmountable, but it does create bookkeeping problems.

SCHIRRA You know that green strip up there? That was the most fun we had in the flight with pictures. Walt was on the right with the movie cameras stripping; Donn was doing landmarks; I was on the left with multispec with southwest US, and I had the red filter, green filter, and each one had a different f stop, and we just did what it said on the back. We didn't have time for spot meters for stills. One of the things we've talked about since the flight is that we have color film, have some kind of color on the back so you know it's color. For the black and white, have the back black, and you know it's black and white.

CUNNINGHAM While we are talking about those backs, they had a piece of tape on it to write what was taken, et cetera. The tape that was there was not very compatible with the zero g pens that we had. It was very difficult to write on them, and I think we ought to have something a little better than that to write on.

SCHIRRA In the old days, Deke, we had a — I know it was plastic, but it wasn't — I gathered it didn't pass the fire board. I remember it was

that rubbed fuzzy plastic, and you could write on it with pencil. We used pencils, but ink would go on it as well. The tape was very hard to write on; and we - of course, in the old days, we wrote with the pentel, and it would go on. But the ball point doesn't hit that fiber; that was the problem.

CUNNINGHAM Moving on to the pictures themselves: we took many, many pictures, probably on the order of 115 or 120 pictures on the S0368, and 400 plus on the S0121. During that time, there was an attempt to make, on several occasions, the same area with both kinds of film as a comparison, and I was thinking primarily of subjective evaluation of looking at the two, at which really looks like the nicer picture. I also feel that during that time, we probably accidentally got some comparisons, too, in certain areas, such as up around the Red Sea where we had S0368 early in the flight, and later on maybe taken the same kind of area with S0121.

SCHIRRA You have a point there. It's something I brought up. If you look at our board up there, you see the strip on southwest US, and the

strip coming down through Africa; that was with multispectral stuff. That was asked for because of 502's pictures. That was one damned rev that 502 made; we made all these revs, we could do the same thing over again each pass because we hit that same pass in Africa every 24 hours. This meant that we could go over it one day with 368, which is the way the protocol should have been; another day with 121; and another day with black and white Panatomic-X. That's the way it should be done, rather than have us try to pick up a whole shaft that another flight had.

CUNNINGHAM That is why I wanted to go to Panatomic-X that last day for some of those ground pictures, because we had enough information on board to make the same kind of comparisons as they were shooting for on those specific spots. Those specific spots, incidentally, were not easy to hit. I happened to notice the pass that I blew over Africa; I happened to notice that we were going to go right down it. Nobody had told us we were; in fact, I noticed, before the flight,

I was going to say, "Well, it would be very fortunate if we happen to make that pass."

SCHIRRA We didn't think we'd have a chance at those; just remote odds. The orbital map on board went to worms because it was a thirty-two and a half inclination. We were at 30; the modes went all cockeyed, all over the place. We just started pulling up program 21 and all that stuff, and finally faked it, but later in the mission, the last day, we asked for updates, and for something like that, I think we probably pushed them off a little too hard; they were turned off by us. They might have said, "This next pass, if you are in position, is ideal for DTO block" that's all; they don't have to give you anything more. That's not pushing; that's just saying.

CUNNINGHAM Another thing that some of this photography suffered from, was the intent from the beginning, that we use a minimum of RCS fuel. On a couple of different occasions, we managed to use a small amount of RCS fuel. Wally would be able to plan ahead a half a rev or so and pulse it in - half way around the world - then

you could end up looking down, and with four windows for photography, there was a pretty good chance you could get a picture of the area.

3.3.3 S005, S006 Photography

CUNNINGHAM There's no question about it - we could have gotten more pictures had we not been constrained on fuel. Going back to the actual hardware itself, there's a problem with the Hasselblad sticking up, and we found dry lube in it, for one thing, and we think that maybe the trigger was a little bit bent. Wally worked with it for some time. This all happened about the third day, and it looked like we were going to have the Hasselblad to out and not get any more pictures because it was - we were waiting sometimes a couple of minutes between shots before everything would recycle back. We used the nose cream to lubricate a couple of the joints; Wally bent the trigger a little straighter, and I think that was really the key, Wally.

SCHIRRA Yes. The little rod that comes through into the magazine - that little flat rod in the back -

CUNNINGHAM We had very little trouble the rest of the way.

SCHIRRA Yes, all of a sudden it started working like a dream from then on.

CUNNINGHAM The other thing about the packs is that the people that stow those things very carefully

stowed every single camera pack with the slider end out. You know, down in the blocks?

SCHIRRA You're worried about fogging the frame is what he's getting at.

CUNNINGHAM Yes. When I restowed them I very carefully stowed them all back again. But it should be a standard procedure when you stow those things to make it foolproof for the guy in a hurry, that he doesn't reach down there and end up pulling on the slider to try to pull it out ... the other. And you also ought to ...

CUNNINGHAM The last one's got a hot frame. Another comment on those backs: well, let me finish up with this stowing these with the slider end in. There also ought to be a piece of tape to write on that's on the end that would be out; in that case, you could see that it had an X on it. The tape is on the side that's hidden, and in order to see if you had a used pack stowed, you had to pull the pack out. It's a small item, but it should be taken care of. The other thing on those packs is that you don't know when you're through, to the last frame. The one with 165 frames on it, the large pack, Donn took

another ten pictures past it and finally called the ground and asked about it. It was reading a hundred and ...

SCHIRRA Tell you why you don't feel torque. On a ground camera you feel the film go on the spool, and it goes into the used side. Here, you can just feel the same all the time. There's no mass or inertia. It's subtle enough on the ground; you can feel it; you can't in flight. The movie camera - you can hear the magazine quit as the load comes off the motor, and it goes ticka-ticka-ticka.

CUNNINGHAM It should have either a definite stop on the thing, or else we should -

SCHIRRA Have a flag come up ...

SCHIRRA And you also ought to mention Dean Edmonds wasn't aware of the fact that we were going to tape those slide backs. There's a hot frame behind that slide. I'll tell you what the Hasselblad does. Very simply, in the magazine, they have a little window that shows you when you wind, and if you don't wind, it stays red ... that's how you know you're out of film, because you don't pop the magazine anymore.

EISELE Another thing that we really ought to bring out here is that we were film constrained on our S005 and S006. We ended up - sure we shot rather freely at the early part of the flight as compared to the latter part of the flight, but for the last 4 days, we started taking film counts and cutting back on what we were taking.

SCHIRRA Just like a survival mode, you start budgeting.

CUNNINGHAM I was going to bring in that there were several items on there that we felt like we had so much that we would rather have had a couple of film packs. We had the rotation hand controller pack, at which I wasted something. We had extra mirrors sitting on my side; at one time,

they were intended to look down the X-axis for some reason, but you could look down the X-axis anyway, without the mirrors. We had the fecal canisters scar weight left in. There were various items that were carried on board that we would have traded for just one more pack.

SCHIRRA We could have thrown away about 15 pounds in there. That's all you needed really.

CUNNINGHAM But at any rate, we felt very strongly that since this flight was about the last one in which we probably would have the freedom to be drifting and taking pictures of the earth, a couple of more packs would have been fabulous.

SCHIRRA We got hung up on that.

CUNNINGHAM Donn went through a night pass when he went all the way down the coast of New Guinea; we were on our film saving phase at that time, and it wasn't one of those areas that was blocked out on the map.

SCHIRRA If we took the pictures, they would have wanted more.

CUNNINGHAM So he didn't take it, and we never got back to take it again. Wally brought out a good point about that map. Seems like the areas that are

outlined to take more pictures are just that, the ones they already have some pictures of. I guess I wasn't as strong an advocate of this until I flew with you, Wally, but any pictures, any good interface land, water, coastlines, interesting geology inland, anything -

SCHIRRA If it gets our interest, take a picture; that's the point.

CUNNINGHAM That's right. I guess we probably could have covered the flight adaquately with two more packs.

SCHIRRA Color packs, 121 or 368.

CUNNINGHAM The other thing is that we haven't seen the 121 and 368 and all that yet, so maybe the 121 turns out nice pictures; we really don't know, but we have taken comparisons. We also think that everybody ought to look through the films and compare, take a look at all the areas we took with the 121 and several areas we took with the Panatomic-X and see if they can't do some of the multispectral stuff with that. Another thing we ought to make a note of is that since we had the Panatomic-X and had poor liklihood of going over the required

multispectral areas and/or getting enough fuel to orient to tape multispectral discrete spots, we suggested and started using the Panatomic-X with the red filter for cloud cover. Essentially, for the first part of the flight, we didn't concern ourselves too much with cloud pictures. We took several interesting ones that Wally had spotted, or we took discrete pictures like of hurricane Gladys -

SCHIRRA I would like to bring this up, a real surprise. We saw hurricane Gladys, but the big surprise to me was the cyclonic effect on top of the thunderstorms. I never even saw it before in the earlier flights, and no one else has reported it, but particularly on our South American runs, every thunderhead had a reverse coriolis effect which you'd expect ... and typical sea shell coriolis vortex, and it was brought to my attention from having looked at Gladys and then here that the thunderstorms all had it, and it was wild because we had a whole string of them coming down across the A of Brazil up there on that map. I wanted to take pictures of it; I took just a couple, but if I had really

been going at it and been more prepared for it, I could have taken a lot of them. I'm sure we will see it, and it's going to shake up the meteorologists. Then I saw it in the northern hemisphere after I was prepared to look for it. I never even heard of it before; I don't think you had either, and it really surprised me, but that's why you need spot meters. Almost all our pictures were with spot meters (that's why you need a large selection of film), but on the same ASA so you don't blow your spot meter setting, so you just set it. That same problem came up, and while I sat there working like a madman to find a sixty-four, the spot meter was wrong; it had fifty and then two increments to one hundred.

CUNNINGHAM I know, and it drives me bats every time. I always sit back and look at that log scale and say now if I'm going up, the numbers get closer together. Does that mean I stay closer to 50 or closer to the next number? I go through that every single time.

SCHIRRA Yes, the thousands bug me. I said years ago, put a little mark on there for 64, a little

mark on there for a thousand where you have the spot meter calibrated.

CUNNINGHAM That's a good recommendation. We ought to have that; we ought to have a mark on there for each ASA that you've got on board.

SCHIRRA Forget the other numbers; they're academic.

EISELE That's right.

SCHIRRA And for gods sake give us back a depth of field; we know what that is. Give us the exposure index number so we can flick around and play the game. You saw my pictures at Indianapolis; not a one of them was a goof; they're all exquisite because I use a light meter, and I use reflex, and I use exposure variable and plain depth of field.

CUNNINGHAM We got a lot of good work together. When Wally and I were both awake, for example, we were always involved in one guy taking the exposure readings, the other guy taking the picture.

SCHIRRA That's why we want them to call them the Apollo 7 crew pictures because everybody was involved. It was either mark planning and attitude way back in China for South America

or spot meters. The camera was back and forth, and I'd rather not go through and research the thing on who took it other than for the rendezvous.

CUNNINGHAM Yes, we told them that everything except the rendezvous or the S-IVB pictures were -

SCHIRRA group pictures.

CUNNINGHAM If possible, Deke, I think we'd like to see all three names on them. They all go out - you know, NASA has that stamp on the back. We think we covered the world pretty well, and it was only because Donn was getting areas that we weren't; we were planning ahead, and I'll tell you, I was glad to hear some of those pictures turned out good because we really put effort into those.

SCHIRRA When the camera jammed, we didn't know whether it was working right, you know, as far as shutters and all that stuff.

CUNNINGHAM Also, we made a great effort to be geographers.

SCHIRRA We'd call up the names of places.

CUNNINGHAM We had a good time. After about 4 or 5 days, Donn finally asked us how we knew where in the hell we were.

SCHIRRA Yes, when I described a city in South America, he said "How the hell did you know I was down there?"

CUNNINGHAM I've been interested in geography for a long time, so we were sitting there discussing historical locations, you know, just like I took that picture of the upper Nile. I took the picture of the upper Nile because I had one art appreciation course at college.

SCHIRRA On some of the cloud shots that were intriguing, I think the experimenters like Ken Maynard should realize that we had gone through enough education in meteorology to realize an interesting cloud formation much like this cyclonic effect which is a new thing, and we're going to be piqued by it, and we don't have to be told to shoot it. There's no reason to have that briefing about what to take pictures of. Those blocks on that and the blocks on our map are sufficient; those are interest areas. I don't think you even need that unless, for example, you come over a certain area where there's a landmark, and we don't have a photograph on it; that should be brought out if it's

a lunar Apollo landmark. We ended up doing that on some occasions. We took pictures of landmarks that didn't have photographs. One landmark Walt was trying to mark on was wrong. We took a picture of it; there was a bridge across where there was supposed to be a channel.

CUNNINGHAM Everybody was looking for it.

SCHIRRA Donn and I were looking out the windows - I said, "That can't be it; it's a solid line." It was; they put a bridge in in the last 3 months. So we took a picture and that landmark is now updated. That's the kind of stuff that photographs are going to help us on. That briefing we had that late evening really was a waste of time. I think the crew, if they're interested - and they all are; you see guys carrying cameras all the time - are interested in photography, they know about weather; they know about geography; and if you have quiet time, you're going to take those pictures.

CUNNINGHAM The only possible thing you might have on there, really, I think if you see a good picture, take it. If there are some areas that are saturated, you might -

4.0 RE-ENTRY

4.1 CM/SM Separation

EISELE — It really looked funny out that hatch window because we were to do a roll. I've seen these rolls, and in fact, it was mostly yaw from my reference. It looked like the whole thing was catty wampus. It looked like it was yawing out of plane or something. The first time it rolled I thought, "What's it doing?" Well I felt kind of funny. I sat over there saying "Look at that fireball!" Didn't you see it?

CUNNINGHAM — I could see a nice vortex down there.

EISELE — Oh, I couldn't see that.

CUNNINGHAM — Oh yes. Looking right out the window.

EISELE — All I could see was a streamer going past the windows. A ... streamer, right?

CUNNINGHAM — No, it was a nice vortex ... and it lasted a lot longer than I expected. It got pink earlier than I expected it, too. Very early.

EISELE — Wally, wasn't it about 25 feet? Just a little fast for a burn like that.

SCHIRRA — I couldn't see it.

EISELE — And another thing. The whole re-entry was kind of an up-phase I felt. A lot longer than the

simulator. It went all the way down to like 65 or 50 000 ft. I felt like things were really going on. The spacecraft was flying itself like mad back and forth.

REP In other words, you could feel it.

EISELE I don't know when it ever really quit being red or out.

REP Orangey red? Orangey red, yes.

SCHIRRA EIR&G red, yes.

EISELE I don't know either; I didn't look at it too much because I was watching the screen. And you know one thing I saw, and I guess I mentioned it. I think that I'm sure it was the service module. I don't know what else it would be -

CUNNINGHAM Oh yes, out that window, even though it was bright inside and dark outside, you could see this whirl of orange lights going around, and I don't know - apparently, after we separated, I think the back was 45 out of plane. Wally must have been rolling and yawing back at the same time. That's the only way I can figure that that window would ever get around to where I

could see that thing. But I swear I saw it going by the window.

SCHIRRA You probably did.

EISELE I mean quite a ways up back.

REP The service module?

SCHIRRA I was planning on looking for it.

CUNNINGHAM Well, the first thing that was anything different than regular timeline was on the EMS deorbit test. They gave you a NO-GO.

4.2 Reentry Parameters

(Everyone talking)

SCHIRRA That was a NO-GO, and the reason for that is - and it's not data that can be supported. The -

CUNNINGHAM Range zero. It failed to test.

EISELE Well, the range zero ...

SCHIRRA Yes, I'm trying to get you the - scroll is the word I'm searching for - the scroll had plus or minus. Point 2 feet per second, and I had minus or plus.

CUNNINGHAM Minus.

SCHIRRA - minus 2.2 feet per second for big - spread.

CUNNINGHAM You mean the counter and not the scroll. The scroll gives you a number, which is .2 feet per second.

REP — In the range zero position.

EISELE — Oh yes, in the range zero position, we had a minus 2.2.

SCHIRRA — And as a matter of fact, it was as we all saw, the darned thing wasn't working on the flight.

EISELE — Just like the simulator.

SCHIRRA — Yes. (Laughter)

EISELE — It may mean that there was something wrong with that - I just wondered.

SCHIRRA — Well obviously that must be it. Those guys might have to use it. It's obvious that that thing failed.

EISELE — That's right, it really failed.

SCHIRRA — We've got to get that on an OPEN.

CUNNINGHAM — It's a fact.

SCHIRRA — We've got to get more of the details. And as soon as we set up do you remember I said it's a NO-GO?

CUNNINGHAM — That's right, I've got it written down a NO-GO.

SCHIRRA — It means to me that we have an OPEN for the next mission. Yes, ...

(Garbled conversation)

CUNNINGHAM Yes, that's right. The other problem, you know, that's going to come up, they are going to say, "well, are you in essence a NO-GO before lifing off?". but I think we should treat this both crew and otherwise, as maybe a separate anomaly. I don't know if it is a separate thing or not. Boy that scroll - I gave up watching it because it was so bad. I saw -

REP I think that's the same kind of thing that's happened to it before.

EISELE I saw minus 300 miles or something like that. The scroll went off into the next blank, into the next ... scroll. It was up around 29 000 feet the last time ... It should have been my second time around. I'd been all the way through once. I went through one scroll, through two test patterns, and the next scroll ...

SCHIRRA It was a dismal failure.

CUNNINGHAM Yes.

SCHIRRA Which is good in the sense that it vindicated our judgement prior to the next mission. But of course, that's the big one.

CUNNINGHAM There's a minor anomaly that I mentioned over the air with the DELTA V counter. You set the DELTA V counter.

SCHIRRA Okay. I saw the same ninety thousandths on it when I tried to get the test 1 position; it did it four times.

CUNNINGHAM I'm glad you mentioned the same manner of problem. I don't think it was covered any place else.

SCHIRRA I did; I wrote it up in the log. Okay.

CUNNINGHAM Okay. I don't understand TM. I do want to make note of the fact that I went to test 1 for re-entry. I got ninety thousandths about three times; I finally cycled back so I could go into zero. Why it went ninety thousandths, that I don't know. That's new to me.

SCHIRRA I don't know.

CUNNINGHAM Of course, it was shortly before lift off.

EISELE Well, the thing that scared me was the time it came up spontaneously; there was no reading on the panel -

REP I have it all written up in the log.

CUNNINGHAM Yes. This was the new ninety thousandths.

EISELE That was the other day, anyhow on the EMS for the tail off? 19-8

SCHIRRA That's for 19-7.

EISELE True. Yes, and it clicked one over for you. But wait, in 38 seconds it'll clock up. Right is three, but anyway - the problem I mentioned over the loop was, someplace there we have to close the gap. The difference between the computer's DELTA-V and the DELTA-V that was set does not equal what they gave us on the entry update as the DELTA-V at tail off.

SCHIRRA We asked that, and that's an open question that they'll have to answer for.

EISELE It was awful close, though. It came out 19 -

CUNNINGHAM Yes, but a conservation rejection -

EISELE But that was when we burned off late, it was very small, about 1 foot in X.

(Everyone talking)

SCHIRRA I thought two in g, and one in X.

EISELE I was amazed I got three ones for the error. I couldn't believe it. One third -

CUNNINGHAM There's one thing about it, you see, on this DELTA V tail off, I was told to tape an update for the chart using 19 feet per second -

SCHIRRA I understand that. We have that in real time, too.

REP Oh, you were talking with reference to your charts?

EISELE Yes. Walt made that point clear before retro and the DELTA-V_c was what it was supposed to be.

SCHIRRA Yes.

REP Okay. That's a good point. The retro burn, I'd say, was just about a perfect getaway.

EISELE How about covering the - I'd like to mention things that we didn't do per checklist of our configuration.

REP Did not do?

EISELE Yes. We left the suit return air valve open because we had the suits open.

CUNNINGHAM Correct.

REP Oh, yes.

EISELE The emergency cabin pressure valve we left on instead of off.

SCHIRRA Right.

EISELE And we had the direct O_2 which I did not play with later.

EISELE Right. And we ought to - we might mention the configuration we did have with the towels - towel bags folded.

REP Okay. Let's go over that. That's very good.

EISELE I think we ought to cover the full details of how we were set up for the landing.

SCHIRRA Well, let's lay that on the - Walt's idea of putting the food bags on the headrests worked out perfectly for all of us; we taped them on. We should have photos of that to document that configuration.

EISELE They kept getting pretty -

SCHIRRA One of two towels in our towel bag and fit those underneath our necks and by our Adam's apple.

EISELE I guess we tried to figure out every way we could turn our neck or head with those helmets off, and the only thing we could see was perhaps banging our chin on the front of the neck ring. We built these towel things and laid the course -

SCHIRRA And vindicate my decision; it was a group decision.

CUNNINGHAM That's right.

SCHIRRA - coming in without a helmet.

CUNNINGHAM The thing that was exciting was - we took care of -

EISELE We didn't discuss this over the air because it is too big a magilla to discuss. It is the pains that we did take this morning to check out: we put the suits on, we tried the helmets on, and we strapped all the way down.

CUNNINGHAM We had more head clearance than we can afford to have.

EISELE That's right. We found out we could possibly get the helmets off, possibly get your nose cleared, but you would never be able to get the helmet back on; you'd have to stow it and have straps all over you. Okay, I'll say one thing, speaking of crew equipment related things: those couch foot pans were a great disappointment to me because North American type guys sort of promised that they would fix those latches on the lids, and they never did. You latched my one side. Yours latched on one side, I think yours latched on one side, and mine did initially -

SCHIRRA But then your foot got caught in it.

EISELE Well, the dog-bone got caught down when I went to the 96 degree position, so Walt got out of his, and we got mine squared away. After that, somehow, the foot band was no longer locked.

CUNNINGHAM Give us the first problem you had though, Donn. The first problem you had was it didn't lock down; it kept folding. Could we go back to one more step?

SCHIRRA We changed the foot pans because we were worried about a land landing. Now, all of a sudden, in real time in flight, a water landing is the crisis.

CUNNINGHAM That's right.

SCHIRRA That's why I'm left holding the bag and, I just don't like that.

CUNNINGHAM Well, I tell you - I think we all agree - mission rules were written which indicated -

SCHIRRA Were violated -

EISELE Yes. - which under certain cases, you would make a re-entry unsuited and then we end up - well, we did put the suits on; we did try the foot pans, and let's say we did have some problems. Now you locked up on one side.

SCHIRRA I fixed that. I pulled the pan -

CUNNINGHAM Would your pan bend with your ankle?

SCHIRRA I couldn't tell.

EISELE No, I fixed his so that he had one pin in but not the other, and initially I reached down and fixed mine, but he couldn't wait ...

SCHIRRA He couldn't get to the outboard one on my left foot.

EISELE But the point is, none of the three of them latched in completely the way they should have; mine was - had neither latch in, and it was just flopping around on reentry.

CUNNINGHAM Right.

SCHIRRA The real problem that I see is they were added to the spacecraft so late we didn't have a chance to really fully evaluate those things in the spacecraft. We had one brief visit down there; I'm sure we could have asked for more. Like any other thing, you are pushed to the limit to get ready, and we didn't really psych out these foot pans as we have in the past.

CUNNINGHAM We uncovered this problem when those foot pans came back from Downey after the fuel restraint mod, and we put them in the simulator, but they weren't fixed. Donn had two problems; one is

if it wouldn't lock up the foldable mechanism, he got down, got it locked up. Then he couldn't get his left foot out. He had to readjust - in order to get the dog-bone out, he had to get his left foot out. He couldn't get his left foot unlocked -

SCHIRRA He technically couldn't get his foot out?

CUNNINGHAM That's right. So that's when I got unstrapped. This was after we all were supposed to be strapped in -

SCHIRRA T-32 minutes.

CUNNINGHAM That's right: T-32 minutes -

SCHIRRA Right about, right close to retro.

CUNNINGHAM I got unstrapped, and I had to really tug his feet; I tugged his heel and got it out.

SCHIRRA I was almost ready to cancel that retro.

CUNNINGHAM I gave it thought, but I figured I could get back in.

SCHIRRA I was watching for that, and you made it. I was going to give it another 5 minutes and then I was going to cancel that retro. I didn't tell you that until just now; I admit.

CUNNINGHAM I was too. We were off our time line.

SCHIRRA Everything was good but the damn couches with the new mod were not right.

CUNNINGHAM Well, after I did get Donn's feet loose, we did get the dog-bone unfastened; we did get strapped in - I think we ought to mention that when we were fat, the couches worked so much easier than I had even anticipated in zero g, very easy handling.

SCHIRRA Off nominal will blow you right out of the seat.

CUNNINGHAM Right. And as soon as Donn got strapped in again his foot pan did not lock down.

SCHIRRA He was stuck with a high risk, and yet here we were putting on our suits for a system that wasn't even going to wear a helmet.

CUNNINGHAM Well, my foot pan apparently was the only one that held. I mean it was firm; it wouldn't go like this.

SCHIRRA Mine held firm; I can say that.

CUNNINGHAM Yours were firm, but only one side was locked up; I think yours was the same way.

EISELE I could slide my feet in and out.

CUNNINGHAM When mine were in tight, I kicked my boots off.

EISELE The point is that it was a late mod, and they didn't fix it the way they should have in the flight check.

SCHIRRA We judged that you were in good shape for knee clearance in the center couch. If it had been Walt or myself, I'm sure we would have scrubbed the retro. But you mentioned the fact that you felt good, that you were safe, that your legs were - it was a high risk, just like that elevator down, like everything else. We went way out on a limb on everything on this flight.

EISELE I'm glad we did it that way. It worked out fine.

SCHIRRA But we lucked out on these high risk areas. Land landing for take off, no doubt; elevator out of commission.

EISELE There's something else I don't mind stressing right here. Upper most in my mind in that whole re-entry as far as risk, and as far as I thought my neck was hanging out, was that whole business they told us about a land landing.

SCHIRRA Oh, prior to lift off?

EISELE No, excuse me. I don't mean land landing; I mean the hard landing on the water.

SCHIRRA The water landing was predominant on our minds all the way through the last day.

EISELE That's right. From the time they started giving us that - the problems with water landing, I kind of quit worrying about the chutes opening and the drogues opening.

SCHIRRA Well, the oddest thing - and I can recall this very strongly in Mercury and in Gemini - we were so upset about the chutes coming out and then pow, no problem. The chutes came out just great; I got chutes; now I really gotta worry.

EISELE That's kind of what I felt, too.

SCHIRRA That is absolutely ridiculous to put a crew in that kind of frame of mind, ridiculous.
I think we really ought to go hit it - get on record with the fact that we were not recklessly coming in with our helmets off. We considered all the possibilities; we picked all the precautions we thought were reasonably good, and as a matter of fact all three of us felt damn secure. I really felt like I was every bit as secure, in fact, I felt more secure than I would have with the helmet with my head possibly bouncing around, as opposed to 8g landing.

REP — You would have had your head secure.

CUNNINGHAM — That's right, I had my head secure with a COMM carrier squeezed between my two-day-old meals sitting there, and I think that the worst possible configuration we could have been in for the landing would be with the helmet unfastened on our head.

SCHIRRA — At least as described to us.

CUNNINGHAM — That's right; it is as described to us. As it turns out, that landing was so soft that it wouldn't have made any difference. Now you might want to argue that point.

SCHIRRA — I'll pick that up for you. Our update was that this landing would have twice the severity of a Gemini, which had a little bit more, I might add, than my Mercury, because Mercury had this flotation bag, air bag, underneath it to really soften the blow, and you were in a form-fitted couch. This was the softest landing I've ever had in a vehicle like that. It made Gemini look like I got hit by a barn door before.

CUNNINGHAM — You've ridden through some mighty good F-38 with me that were worse than that.

SCHIRRA In fact, I've had harder landings on a carrier landing. If you ever watch a guy land in a Demon, for example, his head goes bla-lah-lah-lah-lah-lah as he rolls out on the flight deck. It's that bad. I didn't feel any discomfort whatsoever. I had the doctors check me completely.

EISELE You know, the thing about it is they came in and wanted a good solid whoof, and that's all there was to it. It didn't roll, or twist or do anything.

CUNNINGHAM It turned over immediately.

EISELE Except turn over. You know when the doc, or somebody wanted to get an actual time of landing, we were all sitting there -

CUNNINGHAM Scared to death.

EISELE Scared to death, hanging onto our shoulder straps, heads tucked in, and just waiting for the worst possible happening.

SCHIRRA They were just wondering where all the blood and gore would go. I'd like to say that after retro it was just like any other burn, other than the fact we knew we were coming home.

CUNNINGHAM Yes, you see one SPS burn, you've seen 'em all.

4.4 Attitude Control Mode

SCHIRRA — Right. We cut the residuals down; one was left, I guess. But I felt from where I was sitting that I wasn't ahead by any means. I was with the time line and had a little slop left in it, but I didn't by any means have what I would call a casual time frame where I could sort of sit back and say, "Okay, let's check out the command module RCS thrusters."

EISELE — I remember very distinctly looking at my watch and saying something. I said, "Is it really retro plus 8 minutes already?" Because it just - hardly anything had happened, and we were already 8 minutes into it.

SCHIRRA — We were just taking our time going through the checklist and making sure we were doing right and verifying.

CUNNINGHAM — Yes, checking it off.

SCHIRRA — I really don't think we have time to do that much of a checklist. You might rush into it and frantically do it.

CUNNINGHAM — The only thing we took time to do was for about a minute you let me tweek the stick just to see how it flew.

SCHIRRA That was after SEP.

CUNNINGHAM We had 16 minutes to .05g, and it's a little bit earlier than that for 400 000.

SCHIRRA Okay. Let me go back now; I'd like to describe that C&SM SEP which is a new newey.

EISELE Boy, was that a beaut.

CUNNINGHAM The pyrovoltage just didn't go down.

SCHIRRA The C&SM SEP?

CUNNINGHAM No, we did that at 40 minutes, and we weren't in ground contact, and the tape wasn't running, and we had 36.8 volts and 36.8 volts.

SCHIRRA But we stayed up.

CUNNINGHAM Yes -

SCHIRRA You talking about post-SEP?

CUNNINGHAM No, this is at T minus 40 minutes; we were out of ground contact -

SCHIRRA Oh, oh, okay.

CUNNINGHAM We armed the pyro up, and we had 36.8 volts on the bus.

SCHIRRA Well, when they called back on that, they gave us the GO for it; they never gave us the voltage, did they?

CUNNINGHAM That's right; they didn't.

SCHIRRA What's the point, Walt?

CUNNINGHAM The pyrobattery voltage was still up -

SCHIRRA Yes; right.

CUNNINGHAM And they didn't have any telemetry on the same time. Maybe they got it later.

SCHIRRA I thought you meant you were expecting them to be changed.

CUNNINGHAM No, no.

SCHIRRA Okay. Let's back up to where I yawed left and you waited until I said, "GO" for attitude which is per standard procedures. Then I said to Donn, "ACCEPT", and that was a real powerful blow.

CUNNINGHAM It was a POW.

SCHIRRA Boy, was that a crack. I didn't have any attitude problems, by the way. I was in RATE COMMAND.

CUNNINGHAM No, I didn't feel any transient. ...

SCHIRRA I was still worried about that ...

CUNNINGHAM I didn't hear a bunch of jets firing.

SCHIRRA So, I was willing to expend the energy in RATE COMMAND and have that thing lay in there tight. I just didn't want any problems with it. I know, it was just making these swoosh-woosh-woosh wobbles a bit -

CUNNINGHAM The first thing you said after that was, "Boy, it's a beautiful control system."

SCHIRRA That's right. It worked just right.

CUNNINGHAM The point while they were recalculating real time, but we had only 3600 psi.

SCHIRRA It came up to about 37 or 38 at one time. Remember I said something; it looked like it might warm up. I think it was probably speed loaders you all said were real time.

CUNNINGHAM Yes.

SCHIRRA Okay. Then after SEP, of course, you were yawed back to zero degrees and -

CUNNINGHAM That's about the time I saw that service module whizzing its way through this hatch window.

SCHIRRA Yes. As I was yawing in and rolling in. So I guess, in fact, I started the roll and then you saw it. Didn't I roll from 180?

EISELE Yes. You had to roll 180.

SCHIRRA I'd like to add, too, maybe it's just me, but I definitely was left with confusion about what attitude to be in for a retro roll and for re-entry roll. Don't ask me why; I think it was because I didn't have that damn ORDEAL ball working. That's the reason.

REP That's right, Walt. You see, if we follow the time lapse, as the note I have here, at T minus 12 minutes, it's just a convention, there's no ordeal.

SCHIRRA They ask and what's - Donn saw the program alarm prior to retro as the sextant started roll, roll attitude, and then for re-entry I kept thinking, "Heck, you know something must be wrong." Then I said, "I've gotta roll 180." So that's a real sneaky one that I think the other command pilot should be - or the command pilot should be aware of depending upon how they want to fly. You can really get a circuit play in that roll.

CUNNINGHAM A little out of sequence, but there was something else that was mentioned here; that difference in the way we spinned it all the time. The first time they came up we said that we were going to have to hit COMMAND RESET to get our tapes in the high bit rate data.

SCHIRRA Typical of the range. We have new rules.

CUNNINGHAM That's right.

SCHIRRA They seem to make up rules as they go along.

CUNNINGHAM Well, you try not to have that happen, but I had a contingency entry in here nearly all along that, you know, in case the tape wasn't running I'd go ahead and do that, but I don't think it mattered. Oh, yes, the tape was running. But command - high bit rate, COMMAND RESET, and, incidentally, the tape ran out just prior to landing.

SCHIRRA ... second over burn, there's a whole new picture to me. I wasn't really ready for it.

CUNNINGHAM Okay.

SCHIRRA In that short of notice, but that range was good. Okay. I think my biggest shock was to see those batteries down after SEP. I almost had a heart attack right there on the spot, and I'm glad we didn't have EKG because I would have blown the tracer right off my back.

EISELE Let me elaborate a little bit on this point, the reason that the main buses were down. I had thrown battery C on as per program, battery C; battery A, B, and C were all on. The state of charge on those batteries was something like 26 volts apiece on A and B, 39 volts on battery C; this was a lot less

EISELE

than we had expected to have at this time. It was less than we would have had by the agreement as to what kind of charging we would do on the battery.

EISELE And when we SEP'd, we immediately got main bus A, main bus B undervoltage. We were reading about twenty five to twenty five and a half volts. It was the lowest voltage we'd seen on the main buses all the time. The only reason that I had some confidence that we hadn't glicked anything was I had watched it. I just happened to be watching that when we SEP'd, and it creates quite a bit of consternation.

4.5 Guidance

SCHIRRA Well, it shook me to the core because I was convinced we had a beautiful alignment; we had a beautiful retro burn.

EISELE We did.

SCHIRRA Everything was very exquisite, really exquisite; and then this silly thing coming here -

EISELE That's why I told you that we had everything we had available, that we just had to write it in that way.

SCHIRRA As a result, Donn rode a long time before he -

EISELE I was worried about the guidance system and that low voltage -

SCHIRRA The EMS was bombed out, and we knew that anyway. The only confidence I had -

CUNNINGHAM The result of inadequate charging during the -

SCHIRRA Yes, it changed the -

CUNNINGHAM There are two things there that we have to be fair about in here. It was inadequate charging because they are worried about blowing a battery, which had not been blown with less than five charges on it, and the battery charger did not measure up to snuff.

SCHIRRA I don't think we can blame the range on that. They were informed, and they didn't want to charge the batteries. I'm sure a lot of people were involved, and we'll probably hear more about this subject.

EISELE The only reason we charged battery B a second time, I got the impression, was to check the battery charger electrical system.

SCHIRRA Rather than the battery.

EISELE That's right. If we had not charged battery B a second time, we would have been even lower.

SCHIRRA Well, B didn't go up very much, though.

EISELE Well, C was on both buses then. C shared on both buses, A on A, and B on B.

REP What kind of amperage amp hours did you have on B at that time?

EISELE B had 26 and a half after the last charge and A -

SCHIRRA Was that after the last - that's the number they called up to me one time. You mean they didn't charge it after that?

EISELE No.

SCHIRRA You're right.

EISELE A was 29, and B was 26, and he never charged it after that -

CUNNINGHAM Battery A at the end of the last burn was something on the order of 25 - my data is gone now - and 26 on B.

SCHIRRA We're going to have a lot of fun finding out where we really landed.

EISELE We did have a shock on the undervoltage. We continued on from there. This is where we were going very methodically through a checklist, as far as that goes. We ate up the time that surprised us. He went ahead and configured for ring A the way we had normally done it -

SCHIRRA That's after reentry attitude.

EISELE That's right.

SCHIRRA In the ring A pulse, we called out rate high; and, of course, in pulse it didn't bother me.

We set up exactly as we'd always done. The only part of it was I had to let Donn fly it, and how beautiful that control system is. It is much better than the simulator. Real nice. We could hear every pulse very clearly.

EISELE Really clear.

CUNNINGHAM The controls where you take your pulse were far less in the spacecraft than in the simulator, which made it very easy to ...

EISELE If we could write in whatever our attitude was -

SCHIRRA I don't think we ought to worry about flying that thing in direct.

EISELE No. I got very jealous.

SCHIRRA Beautiful. That spacecraft should go into the Smithsonian. It's beautiful; it deserves it.

CUNNINGHAM I guess we'll have to go out and give Healey one big plug.

EISELE Oh, we really will.

CUNNINGHAM Back tracking just slightly: Since we did burn the residuals out, it turns out that the post retro update was not as necessary as it's been. Every time we've sent it now, we start burning the residuals out. We go with a pre-burn update, which simplifies a lot of problems, and

if we always burn the residuals out, we don't have to worry about getting that post burn update. It came pretty close - the post burn update comes awful close to blackout.

SCHIRRA — I caught my fourth channel without you calling it. I don't know whether you noticed it or not.

CUNNINGHAM — Yes, I know; I called it anyway.

SCHIRRA — In reference to the fourth channel, we go into any SPS burn with one roll channel disabled. After the retro burn or any of the rendezvous SPS burns, we started to take out the residuals, and I need that fourth channel. I got it this time, after goofing that last simulation.

4.6 Visual Sighting and Oscillation

CUNNINGHAM — Did we mention that, Donn? Donn does think he saw the service module when we went back in -

EISELE — ... back in on the ..., yes.

CUNNINGHAM — I had planned on looking for it. At one time, we even discussed taking pictures of it. I'm glad we didn't even plan on it. I was so busy reading the checklist and putting checks on it that I didn't see a thing out the window.

SCHIRRA — Let's go back to what we did see out the window, which I thought was new.

EISELE — You're talking about -

SCHIRRA — - pretty spectacular. It was that pink cloud.

EISELE — Yes, wasn't that pretty?

SCHIRRA — It was the most delightful light pink I've never seen in Mercury or Gemini.

EISELE — It was early and high up -

SCHIRRA — Very high, way up, long before ..., I was still in ...

EISELE — It was a beautiful pink. In fact, I can't help but think we must have been heating a little.

SCHIRRA — Oh, we were; we had a little energy going for us.

EISELE — Very strange.

REP — Do you think it was off the spacecraft or -

ALL — Oh, yes, yes, it was. It really was.

SCHIRRA — ... looking for, and I looked.

CUNNINGHAM — I'll tell you something else that was - It was very high and before you start getting ...

EISELE — A light pink like a pink sherbert. It was very pastel. It was really a very definite contrast between that and what I saw later. Actually, the impression is that it was something external to the spacecraft, just back around the side -

SCHIRRA — I couldn't believe -

CUNNINGHAM We were in sunrise right there, and I'm kind of wondering if sunrise might have something to do with it.

SCHIRRA We were - I never saw the horizon, by the way, ever, on the re-entry.

EISELE I was a little worried about that.

CUNNINGHAM I did. I saw it in the hatch window.

SCHIRRA Did you?

CUNNINGHAM I remember I made the remark about how well the window marks line up.

SCHIRRA Of course, we'd made up our minds we were going IFR anyway.

CUNNINGHAM That's right, and we turned all the lights up. We blocked the sextant star.

SCHIRRA I think you've got to make up your mind that when you can't go outside, you check if you buy the star sighting ...

CUNNINGHAM I had a little bit more time from here on down to rubberneck. That's when you and Donn are sitting here discussing buying ...

SCHIRRA You said rubberneck. They look out more; I'm busy.

CUNNINGHAM Well, I was sitting there, and I -

SCHIRRA Why don't you describe the lighting phenomenon?

CUNNINGHAM Yes, I was watching a lot out of the window, and I know I called you guys' attention to it one time. There was little, well not very little, sometimes -

SCHIRRA - It was blobs -

CUNNINGHAM - It was big blobs coming off. I thought it was some of the ablative area breaking away. Looking at the spacecraft, there aren't too many big blobs missing out there. You could definitely see a vortex behind it. I was looking out that window and watching.

SCHIRRA It was a tube; I saw that.

CUNNINGHAM It was a tube, and it was twisting.

SCHIRRA In contrast, in Mercury and Gemini, we had copper beryllium up topside.

CUNNINGHAM Yes.

SCHIRRA Were there any green rings?

CUNNINGHAM No, no green ring at all. And it got lighter as it went back, but I could see the vortex; it was actually twisting up.

SCHIRRA It was a hot ride to - Well, let's come up to the one that shook the hell out of me. The one that scared the hell out of us was when something on my side went pow -

EISELE That's right, and when I saw it -

SCHIRRA Donn said we lost pitch and Walt said "What was that!", and I'm trying like a madman to bring all the thrusters back on the line.

EISELE We nearly went back to two rings, using everything we could get. But what happened there: we'd been pulsing pretty heavy in pitch and yaw, you see, cycling fairly well -

SCHIRRA We were rotating, reversing bank.

EISELE Yes, and the system was fighting all these moments that was going on. All of a sudden, this big hunk of whatever it was went POW. I was looking out the hatch window, and this big hunk of yellow -

SCHIRRA When I looked out my window, I thought the window - the outer pane of the window had blown out.

EISELE You must have seen the same thing and all of a sudden. At that time, the thing seemed to stop firing. I said "Good grief, I've blown a pitch thruster."

CUNNINGHAM Wally had a hard time getting over there. It was just like zap, they're all in.

EISELE Apparently, what happened is that one or more chunks of the ablator came off rather explosively.

I don't know how it happened. They just blew off. At the same time, we were into the atmosphere far enough that we had aerodynamic standing and didn't need the tip because you looked at the way the rate meters were moving. They really weren't going very far at this point. I think that's what happened, and we got faked out.

CUNNINGHAM Was this before or after we bought the computer?

EISELE Oh, this was after that.

SCHIRRA This was after we had reversed back.

CUNNINGHAM Okay. It was after we bought the computer.

SCHIRRA Let's go back to buying the computer now, and that was your job. No, I had already written off the EMS. That was a flop. ..., I want to give you a big fat plus for hitting the mark on the philosophy of EMS. That was something I wasn't even ready to do. I was looking at it very disappointed. It just wasn't working right at all.

EISELE He made a comment to us that you're not allowed on the loop.

SCHIRRA I would like to have you analyze how you bought the computer, if I may.

EISELE Well, we were just following our standard rule which said we would not believe the computer to the extent of doing the CMC AUTO until it did something smart with its bank angles. It just took this one forever to deduct and command a bank angle other than zero. I think part of it is that you maneuvered to a 55 degree bank; it started over-anticipating a little early.

SCHIRRA No, you gave me the .2g, and then I went for it. I didn't go any earlier then that.

EISELE I think you did.

SCHIRRA Negative. In fact, I was behind you. Because at that point you said "Is that .2," and I said, "No, 67." You said "Roger," and then I started over. In fact, I didn't come over fast enough; I was real slow.

CUNNINGHAM Here's the thing that got me about it. I was listening to you -

SCHIRRA It's supposed to be 20 degrees per second going over there, and I didn't go like that.

CUNNINGHAM Well, I was listening to your conversation over there, and we were anxious to buy the computer to get the guided reentry.

SCHIRRA Well, I wanted that.

CUNNINGHAM Wally was pumping Donn about -

SCHIRRA Well, I had a good feeling -

CUNNINGHAM - is it okay, and Donn was holding off to the last minute. You know the last minute is funny. The last minute seemed like a long time, but it is the same place he always buys a computer, after the downrange area gets down to less than about 10 miles.

EISELE The downrange area has to go down to about 9 miles before that thing will command the bank angle other than either zero or 55.

CUNNINGHAM That's right.

SCHIRRA I'm sitting there saying, "Oh, Donn, please buy ..." Well, we have to wait till the downrange area got down there, and all of a sudden ...

CUNNINGHAM I tell you, I think that's in our minds. I was sitting here doing the same thing. We knew that computer was consistently giving us - you know, a hundredth of a degree in both -

SCHIRRA We saw it in sections - all the way through the mission, every inch of the way. If we had to go that dinky old 55 degree bank for re-entry and go somewhere in the Atlantic - that's all

I can give you - I would have cried; I really would.

CUNNINGHAM When he finally did buy it, I think we bought it at the right time, and it was kind of a nominal time.

SCHIRRA You notice how he gave it to us? Voom! ... he flew it right in for us, and she flew. We were watching him like a hawk.

CUNNINGHAM You know from that time on, I was impressed by the way that really blasted across to the other side.

SCHIRRA That machine is built to do the 20 degrees per second.

CUNNINGHAM I know, but boy, I'd look out the window -

SCHIRRA - goof this little machine by not rolling fast enough.

EISELE — Yes, Wally flew in a normal, smooth way, I think, but when that thing got in reverse -

SCHIRRA — That thing was wild the way it reversed. It even did one around the bottom which I got a big kick out of. It was smart enough to do that, and I wasn't smart.

EISELE — I didn't even notice it.

SCHIRRA — Yes, it went around the bottom.

CUNNINGHAM — That was late, that was after we had already killed off most of the error. Oh, yes, there was a lot of - it got down there where there was a lot of ... It would just go swish, swish, swish. Well, it had to swap sides to take out cross range that it still had ...

SCHIRRA — By the way, I want to go on record ... the leather elbow, pipe smoking boys did very well on this mission. You've got to hand them that, and I retract all my snide remarks except for the fact that gimbal lock still terrorizes me.

CUNNINGHAM — So the next surprise I had was after drogues. We started steaming up.

SCHIRRA — Oh, that's the windows. Yes, the windows occluded due to cloud moisture.

EISELE Yes. They were cold like a T-38 will steam up -

SCHIRRA That's right, and then it just started clouding up, and I said "we have an IFR clearance straight in, no delay expected."

CUNNINGHAM There's one other thing to mention that the guys might be surprised about. There were fumes in that cockpit.

SCHIRRA Yes.

CUNNINGHAM I didn't know whether they were ingested fumes from the RCS or whether they were pyros. Donn said they smelled like pyros.

SCHIRRA No, that wasn't RCS, that was pyro. It was detectable some time after drogue since we hadn't really brought up the cabin yet. It was after drogues, some time between drogues and mains.

CUNNINGHAM I think it was also the same kind of area where we -

4.7 Drogue Chute Deployment

SCHIRRA Let's get back to drogues. By the way, the drogues didn't squirm; I didn't feel this bumpy road stuff that I did in the Mercury and Gemini. Very steady, very solid. You could see the drogues working, but they weren't

squirming, a real vibrant ride. I looked and said "gee, it's not doing very much", but the spacecraft was stable on drogue. Very stable.

CUNNINGHAM Oh, yes. And I will tell you one thing that helped Donn and I, not having been through this before; Wally told us to stand by for the dereefing and that the drogues were really going to be a shock. I really wouldn't have expected the drogues to be a shock, and there wasn't a terrible pulse, but I wouldn't have been braced at all if he hadn't said so.

SCHIRRA I expected more than we got, frankly.

CUNNINGHAM And I had one brief flutter in my heart when the cover came off the drogues.

SCHIRRA No, that was the pilot chute that went out with the apex cover.

CUNNINGHAM Yes, and it kept right on going ... Well, I'll tell you my thought at that time. My thought at that time was "well, we've got another drogue."

4.8 Main Chute Deployment

SCHIRRA Well, that's not true. What went through my mind was - "okay, we've got to get down to 5000 feet, and the card says 7000, and I've got

to start getting RCS logic back on, ELS manual, all that good stuff. So I can fly the ... down to 7000 indicated to get the mains out. And all of a sudden click, click, click". I looked at that water, and the chutes went out.

CUNNINGHAM I'm sitting here helpless over on the right side, and all I could think was, "well, we've still got another drogue," and I remember thinking "gee, that first one failed, that second one might fail too" ...

SCHIRRA You know, I've seen movies of the drogue, and yet they didn't look like those movies, and those beautiful mains when they came out ...

CUNNINGHAM Well, in between there, incidently, the cabin pressure started increasing sooner than the simulator. I think right after drogues I started seeing cabin pressure coming up.

SCHIRRA You had me go to dump.

EISELE Well, the thing about going to dump there was that I wanted to get rid of that Delta P across the cabin lower. They'd like to have us go to dump, down about 3500 feet, and I didn't know what we would be doing at 3500 feet. We had

gone to dump a lot of times ... It's a good idea to get that Delta P out if you can.

SCHIRRA That Delta P light? Yes, you always put that out, if you can.

EISELE So anyhow, we've got about 50 seconds between drogues and mains. Many times in the simulator, we've gone to dump because the cabin pressure wasn't increasing, and it seemed like a good place to do it. We went to dump, which did speed up cabin pressurization, and we left it in dump until we closed them below 1000. You know the thing that struck me about both drogues and mains, the reef, and disreef, were that the opening shocks were very mild, more so than I expected. I looked up, and they just quietly opened. There wasn't any delta g at all. We were bracing ourselves. We had discussed the procedures for reentry, incidently, like grabbing hold and clasping your arms together and holding your shoulder harness. I did that each time Wally had told us to expect a shock, and it turned out that the shock wasn't that bad.

SCHIRRA Everything was less, which was great. Before I forget, the max reentry g I saw was 3.2. I might shade it to 3.3. That's all.

EISELE Well, it seemed to drive up to some level like 3 plus and then just hold for a long period of time. Yes, I looked over there a couple of times; it was almost a constant g.

CUNNINGHAM There was a long period of constant g, and it seemed to me that there was more going on at re-entry, for a longer period of time than we were used to in the simulator. All the way down to 65 000, I felt like there was a lot going on; and in the simulator, I always get the impression that for some period up above 100 000, we're just waiting for 65.

SCHIRRA I felt we were just with the time line all the way down, maybe oh, 30 seconds to a minute and a half ahead but never comfortably ahead where you could sort of sit back, other than the times that the darn ...

EISELE We had about 4 minutes to .05 g with nothing else to do.

SCHIRRA Now the other thing we always worried about which we simulated failures with was the ...

SCHIRRA altimeter. Now that beauty was on! The drogues came out right on the little tick mark which is exactly 24,000.

EISELE An anomaly showed up here. We did go to dump at 17 000 or some place around there, and it wasn't because the cabin pressure wasn't increasing. It was to take care of any excess Delta P down lower. The cabin pressure did increase, and the mains came out. They were beautiful, but we were in an overcast, and it wasn't the same as looking at it against the blue sky. We were IFR, and we started to fog up inside. At this time, I was sitting there thinking "well, we'll break out at 2000."

SCHIRRA Wasn't that wild, the way the wind reports changed? Hours before retro, it was CAVU; then it started closing in and closing in; the winds went up; the clouds came up; next thing you know —

CUNNINGHAM Well, quite frankly, we recovered in weather that I didn't think they - recovered in in manned spaceflight.

EISELE Apparently, they do. I think we have a new parachute.

4.9 Communications

CUNNINGHAM At any rate, I was sitting there expecting to break out of the overcast at 2000 feet; and at 10 000 feet, we went through the checklist items. I turned the VHF A simplex and the beacon ON.

SCHIRRA You did turn the beacon ON? This is a big problem.

CUNNINGHAM Yes, I turned them both on. We were transmitting and receiving. Apparently, the beacon was not putting out until they got a cut on it just before landing.

SCHIRRA Yes.

CUNNINGHAM Donn made a voice report which apparently wasn't received, incidentally. We went through the normal checklist items, just like it's called out, and they didn't get a beacon until after we had uprighted after landing.

SCHIRRA No, that was the beacon light, which was on me per checklist. That was why I was confused with you? Air Boss said he could not see the light. I didn't turn them on, and I wouldn't turn it on in daylight, normally. This wasn't really something on my mind, but I did goof on the - we

SCHIRRA got into stable II and of course I was worried about the fan. Donn was getting kind of queasy.

EISELE Queasy, hell! I got dog sick after about 5 minutes of that.

4.10 ECS

SCHIRRA Let's get back to rate of descent. It looked very good. I was timing it. Then I noticed our windows started occluding due to the moisture condensing on the windows, and I just don't know. I don't think I ever called out altitude as often as I did today with you fellows.

CUNNINGHAM Oh, yes, in fact, this is funny. This is the only real one that I've been on, but we did everything much more thoroughly than we ever have in the simulator.

SCHIRRA I was terrorized about the landing, so I kept calling at 1000 feet. I wasn't sure 1000 feet was good, so I wanted to be in position myself; and I said "okay, I'm on the sticks," remember?

REP I might mention that you said the mains came out at 11 000.

SCHIRRA About 10 500, almost 11 000. We never got that far away. Remember, I never got an altimeter

SCHIRRA error call up. We'd rehearsed that with Houston, but I never heard it.

CUNNINGHAM You got an out-of-date setting.

SCHIRRA I wanted a setting very badly. I wanted a number on which I would deploy the mains. I never heard that number for the recovery area. I should have asked for it, but I think they're supposed to remember that more than I am since they're going to play the role of adviser instead of commander. Whenever the mains did come out, about 10.5M - 10.6M they looked great. I called out altitudes to Donn. He was interested in lock up, and I locked up and kept calling hundreds of feet.

CUNNINGHAM I heard 600 and 400.

SCHIRRA I called 300, and then I said, "I'm not going to talk any more. I want to hold on."

5.0 LANDING AND RECOVERY

5.1 Impact on Touchdown

CUNNINGHAM — I turned off the main buses between 600 and 800 feet, so it actually read 100 feet. We were still airborne, and then zero feet - splash. Nice quiet little drop in. We slotted, and immediately we were stable II.

EISELE — The chute took us; I'm sure we landed downwind rather than upwind of the chute. The chutes went right over us and flipped us into stable II. We went through our normal egress procedures.

5.2 Postlanding Checklist

CUNNINGHAM — I was surprised at how fast we got the suits off.

SCHIRRA — That was great.

CUNNINGHAM — You had your two switches. I hit the circuit breakers, and they were off immediately, but we were already stable II.

SCHIRRA — When I looked out my window, I could see the chutes sinking.

EISELE — I didn't notice it till later. They were underneath us.

SCHIRRA I could see the dye marker coming out. I was very surprised because I hadn't thrown the switch, but there was the dye marker.

EISELE Well, they explained to us later here that apparently the dye marker leaked a little bit.

CUNNINGHAM Well, I don't know that it should leak, but I guess it did.

EISELE Well, it's still undeployed on the upper deck.

CUNNINGHAM I was a little concerned about the swimmers - deploying. It was sure hell about that. I didn't want to get them all green.

SCHIRRA So then in stable II, we elected to light off the compressors for the prefloat bags, so we kind of cluttered up on wave action, and it didn't work. But we ought to mention that we were in stable II and went through our post landing checklist. We knew there was a 10 minute cooling period in stable II. Donn started feeling kind of bad at about -

EISELE I wish I hadn't thrown up -

SCHIRRA - Four minutes, and I wish he had said he was feeling bad, but you know what he said? He said "any of you guys feeling sick?"

EISELE I was looking for company.

CUNNINGHAM I don't know if we mentioned it earlier; I don't think the Range knew it, but Donn and I at least had both taken nausea pills.

EISELE Marizine is what it was. Wally did not, being an old salt.

SCHIRRA What's that again?

CUNNINGHAM I felt like I was carrying it fairly good, but I was not all that confident that I wouldn't get sick if we had not, you know, stayed in the spacecraft a little bit longer.

SCHIRRA I didn't think that Marizine was very effective.

CUNNINGHAM In fact, Donn was telling me -

EISELE That was what I tasted when I was gagging; it was the bitter taste of the Marizine pill coming back up.

5.4 Spacecraft Status

SCHIRRA We had to use the flotation bag to bring us up. We tried to press the circuit breakers and brought them all on.

CUNNINGHAM The post flight bus circuit breakers and the post landing circuit breakers. I tried to find the suit decompression circuit breakers.

SCHIRRA What surprised us was that we did not see the flotation bag as we did in the water egress

SCHIRRA — training in both the Gulf and in the tank. Incidentally, the cooling period was supposed to be in 10 minutes, and we were timing it out. Donn had gotten out of the couch; he really looked like he was suffering. At 8 minutes, we turned on the compressors and started upright-ing. We figured it was a bit of hedge in there.

EISELE — I felt very green, but not with envy.

SCHIRRA — He looked white. He was carrying on admirably. I know he pulled the pyro circuit breakers down there when I thought he was going to die, but instead he was going to throw up.

EISELE — My last heroic effort before I could finally pull those circuit breakers.

CUNNINGHAM — When he got it all over himself, he was a scientist then. When Donn finally gave up and admitted he was going to get sick, you should have seen the wrestling we did around there to try and get him a bag in a hurry.

SCHIRRA — We wanted to help because we all realized if one guy gets sick, the other guys probably will. We had some very great sound effects. I wished you could have recorded those.

CUNNINGHAM Oh, yes.

EISELE Oh, no!

CUNNINGHAM While we were in stable II, I thought that we had contact; recovery 1 spotted us, and then recovery 3 was over there in a hurry.

SCHIRRA No.

CUNNINGHAM You were talking to him, I think.

SCHIRRA No, I wasn't talking in stable II.

CUNNINGHAM I heard you tell somebody we were in stable II. We were all ready in contact, I think.

SCHIRRA You might think that I did, but I doubt that anybody heard me. There is no way. My window wasn't clear. The window was fogged.

EISELE The windows were filling with water, and he was saying shipping water, which is very bad form.

SCHIRRA When I say shipping, you interpret as meaning coming inside the spacecraft.

EISELE That's what shipping means.

SCHIRRA I meant shipping it into the interspace between the windows.

CUNNINGHAM There are two panes between us and the water.

SCHIRRA I don't believe the spacecraft took on any water.

CUNNINGHAM No.

SCHIRRA Okay. Let's make that clear. The fact that the water came inside up the two panes away from it washed out all of those problems we had on the windows. There was nothing there. It's what happens on every flight.

EISELE And it's funny too, the water seemed to drain out before we ever started uprighting.

CUNNINGHAM I think it's going into the insulation.

EISELE They've probably got a lot of water sitting out there in it.

CUNNINGHAM Remember, we flipped over into stable I about 4 minutes after we started inflation?

SCHIRRA It took about four and a half minutes after inflation, and we kept the float bags running for a set 2 minutes; and since we hadn't used the full seven for uprighting, I left them running about for 4 minutes. I never saw a float bag.

CUNNINGHAM I never did either, till I got out.

SCHIRRA They weren't fully inflated by the way.

CUNNINGHAM No, we probably could have run them for 7 minutes plus 2 minutes, 9 minutes all together, something like that.

CUNNINGHAM In the egress training, they were tight as a drum. We heard both compressors which cycle effect the heat ... revolving systems in the heat band.

EISELE Incidentally, while we were in the water, I turned the VHF and the beacon off because we inverted. I was actually just following the checklist by rote down here.

SCHIRRA What was the goof on coming up, Donn? When we got back up on stable I? I looked down at the post landing vent control, and it was normal. I put it in open, nothing happened; I put it back to normal, nothing happened.

EISELE But it seems I forgot all about the power switch from low to high; that's why we didn't get venting.

CUNNINGHAM I don't know if you heard me; I called high.

EISELE That never got through. We had this going on.

CUNNINGHAM Well, this was afterwards. It was after you had gone through all that, and I read this checklist again, but I couldn't hear - Donn was doing his bull bellow out there. We felt we couldn't hear what was going on.

5.5 Battery Power

EISELE — Of course, I had a goof right here, too. I had left the switch. I thought I was monitoring batt bus, but I had left it on main bus.

CUNNINGHAM — I got down here and said if the battery voltage is less than twenty seven and a half, take one of the batteries - take two of the batteries off the line, and I was reading zero.

SCHIRRA — Oh, swell.

CUNNINGHAM — And I thought, "well, I'm not going to take these batteries off the line until we're up anyway." Then I remembered battery bus; we were reading about 29 volts on each battery bus - something like that - between 29 and 30 volts.

SCHIRRA — Why don't we take a break here? I think Donn has a couple of questions that need just Donn talking. Go ahead.

CUNNINGHAM — Yes, Donn has mentioned that they had some kind of an anomalous behavior with the beacon. They never did receive the SARAH beacon or received it only very briefly before splashdown. I would estimate that it was probably about 9 000 feet when I turned the VHF AM to

CUNNINGHAM simplex A, the beacon ON. And then when we went to stable II, I turned both of them OFF. Then when I got down the checklist, it called to turn them OFF, and I had already hit them both OFF. When we uprighted, I turned them both ON again. No, when we uprighted, I first turned the beacon ON, and I didn't have the simplex A ON yet. I had beacon ON for a while before I went back and turned simplex A ON. Yes, I think you tried to transmit, and it didn't get out. It would seem to me that a possible problem here was a kind of slow deployment of that recovery antenna. There's two separate recovery antennas, and I think they've had problems before. Donn mentioned test articles. They had a little trouble with those antennas deploying.

SCHIRRA That's how they gave up so-called VHF, because it didn't deploy.

CUNNINGHAM Oh, okay.

SCHIRRA That's what you're thinking about. They call it an HF. We're using UHF which we call VHF, and we're using VHF which they call HF, by inspection.

CUNNINGHAM Well, at any rate ...

EISELE It finally gave up a radio set to recovery.

CUNNINGHAM We got down to the point right here where we had done everything we could. You were in radio contact.

SCHIRRA Yes, I talked to Air Boss.

CUNNINGHAM The next thing I would have had to hit on the checklist would have been low powered check list. I could see no reason to do it since we were in contact.

EISELE I could see him. Remember, I said that?

SCHIRRA Remember, I asked Donn and he said he saw him? I asked him one thing. Now, what was that? Oh, I know. I didn't ask him. I asked him to give me the word on whether I was aboard the grappling hook or not. He said the last we heard, we had some 20 odd knots of wind, which was going to blow us downwind.

EISELE I'd like to take a couple of minutes just to mention the suggested, but mainly the things we heard. We've already talked about the SEP which was a big surprise and a hell of a bang. The next thing that happened, and actually

EISELE before then, was about three-quarters retro when we pressurized the command module.

SCHIRRA Oh, yes, the mode A.

EISELE We proved the regulator sounded just like hydraulic chatter in a T33.

CUNNINGHAM I immediately felt like it was a valve chatter. It was hit with some pressure all of a sudden and then backfired.

EISELE When I heard this gurgling, I hit the pressure switch. That's when I switched. Then I turned the propellant isolation valve on, and we heard all this gurgling noise.

SCHIRRA I'm glad you brought that up because .... I was convinced that it was a waste of time to check it out, regardless if it was good.

CUNNINGHAM I might mention that as soon as he did that I said, "Look, I can hear it going down the lines." You could hear it run through the lines.

SCHIRRA I am convinced it is a waste of time to check out those RCS. You still .... Everybody else hesitates. All the other guys say "oh, you should check it out." And I said, "What are you going to do on a lunar mission?" Well,

SCHIRRA — you could hear the squibs go; you could hear lines gurgling.

CUNNINGHAM — There's no lack of confidence. We heard the whole thing right down the line. You don't have to get the chatter, incidentally, to know you have pressurization. The pressure does come up.

EISELE — I was not aware of any particular acrodynamic noise during retro.

6.5 Electrical Power

6.5.1 Fuel Cells

CUNNINGHAM — Another thing that was performed at this time was venting the batteries; and in venting the batteries, I noticed that the pressure was initially about 1.4 mm, excuse me, it wasn't 1.4 mm. The voltage on systems test meter for 4A position was 1.4 volts. When we vented it, it went down to about .6 and seemed throughout the flight to tend to maybe outgas a little bit more; and in doing our battery venting from then on, it worked its way on down to as low as .25 volts at one time. New subject. This time, we're covering electrical power for the orbital phase of the flight. It's paragraph 6.4 in the debriefing guide. Number 1 is fuel cells, and I'll cover these item by item. The PH high indicator — PH high indicator had shown no changes throughout the flight. Fuel cell radiator temperature low, never made any change from its gray bar state throughout the

flight. Fuel cell flow and the module - Okay. Starting over again on the subject of fuel cell flow and the module temperature indicators: the fuel cell flow, the H_2 and the O_2 flow, always appeared to run very, very close to what you would expect for the loads that the fuel cells were under. The module temperature indicators, however, did show anomalies. The skin temp was consistent with the performance of the fuel cell. However, the condenser exhaust temperature does show anomalies. It looks like we have some kind of possible control problems in the bypass valves on the - probably the primary coolant loop in the fuel cell. The fuel cell 2 started showing high indications on the condenser exhaust temperature at approximately 162 hours into the flight. This was a slow increase; the ground apparently noticed the trend a little earlier than we did. We were watching it, however, and standing by for a master alarm should it reach the trigger value of 175. It turns out that the fuel cell did continue to climb.

triggered off, it was rather annoying, in that the temperature was not constant up there, and it triggered on and off for some time before it maintained steady above it, and we had a lot of master alarm activity for fuel cell 2. From that time on in the flight, the standard position of the fuel cell, time shared meter was for fuel cell 2. The temperature continued to climb; we opened the circuit of the fuel cell, and it dropped very rapidly back down to its normal range, but we started seeing an anomolous behavior in fuel cell 1 at this time. It appeared to be a sympathetic reaction in that the fuel cell 1 condenser exhaust temperature began to climb when fuel cell 1 was called upon to take more of the load. This is the only time throughout the flight when we open-circuited fuel cell 2 that we saw this behavior. However, it leads you to believe there is something maybe slightly squirrely in these glycol coolant loops. This ties in with the fact that a little bit - in fact very late in the flight, the condenser exhaust temperature on fuel cell 3 dropped down low enough to trigger off a condenser exhaust

flow light. But the real problem - there was little or nothing in the control loops for fuel cell 1 and 3 as compared to fuel cell 2. Fuel cell 2 continued to go up and down throughout the flight depending on whether it was under load or not. On the drifting flight configuration, fuel cell 2 came down and carried its share of the load just fine. Fuel cell 2 was the one that was shared on both buses, for example. It seemed to run just about 2 amps higher in current but not enough to make any difference. As soon as you powered up the SCS and G&N, fuel cell 2 continued to climb. On one particular burn, I was a little bit concerned about hitting the 200 degree limit, just prior to the burn and just after the burn; it apparently peaked out at 195 and started down again right after, when we started powering the loads down again. Apparently, there was much discussion on the ground about what this limit really was; we weren't aware of that, and as far as we were concerned, our onboard consideration was to keep it below 200 degrees. This was what prompted my concern for the deorbit burn;

I wanted to bring the power up a little bit earlier before deorbit. Donn was going to be up by himself for awhile, and he could get a one rev jump on getting the alignments and getting suited so Wally and I would have a free run of the lower equipment bay when we got up. He did get powered up, and the fuel cell temperature started to come up; I had asked the night before to power it up like that but then open fuel cell circuit 2, so that we could save it and let that temperature increase occur much closer to the burn. The ground apparently felt that we could go ahead and leave it on the line and power it up very late; they had decided to open-circuit fuel cell 2 also. So we ended up open-circuiting fuel cell 2 late in the flight, also. I might comment that the first time we open-circuited fuel cell 2, it was open-circuited at 163 hours, stayed open-circuited for several hours, and at 163 hours and 45 minutes with fuel cell 2 off the line, we had a transient main A and main B undervoltage. This was probably due to some cyclic load triggering the fuel cell down below the twenty-six and a

quarter for the main buses. It's the only problem we really had, undervoltage; we had fuel cell 2 off the line until late in the flight when we open-circuited it again. At 232 hours and 45 minutes, fuel cell 3 showed a low condenser exhaust temperature. It was apparently anomalous; it came back in and worked fine since. I don't know if that is one of your items on the open anomalies.

SCHIRRA Walt, that happened on my watch there just before entry, and I asked him if we had a cold one and a hot one if we could swap the loads around, and they said they were considering that, but they never came back with any statement one way or the other, so I just let them run the way they were. Number 2 didn't really get all that hot right then, but it did later on after you guys were awake. Got up to about 180 or so, right around there.

CUNNINGHAM At the end of the flight, it turns out that we brought it on the line - about 5 hours prior to deorbit, I believe - and at 257 hours and 52 minutes, the ground concurred. At that time, the total load was about 70 amps, and fuel cell 2

condenser exhaust temperature was 185, and we had about an hour and half to go before deorbit, and fuel cell 2 was open-circuited. It dropped very rapidly and nicely down to within limits, or almost down to within limits again. At 257 hours and 54 minutes, main A and main B undervoltage lights came on; this was associated with activating the secondary coolant loop. When we turn the secondary coolant loop pump on, we put it on AC 1, but because of the bi-loads and all, both buses pulled down momentarily under the trigger level, and we had main A and main B undervoltage lights. We reset both the buses, and it was all okay. I believe that covers in fairly decent detail the fuel cell 2 problem. I consider it an open anomaly. It's nothing I wouldn't go ahead and fly with; I think that it would have been very nice had we gotten the fuel cell 2 back. It seemed to be behaving in a manner which was rather strange. I think it's associated with the gycol loops in the fuel cells themselves. However, we could have gone for a long period of time open-circuiting the fuel cell at high condenser exhaust and putting it

back on load when the skin temperature got down to 375. It's an anomaly. It would be well worth looking into to see if we can't handle the problem one way or another.

REP That is worth a little bit of laveration because from a crew point of view, after you're flying those late changes just don't sit too well with you in flight; and in this particular case, I worked with the fuel cells for a long time before I was on the Apollo flight. I worked with the malfunction procedures. I worked with the North American engineers on it, and they were adamant in the malfunction procedures that 200 degrees was the place to open-circuit those fuel cells. It's my understanding that when it looked like we were going to hit 200 degrees, we had a letter come from North American saying that 220 degrees was good for 50 hours or some period of time and even later, 250 degrees. Now, we felt like we got smarter in flight about the systems; maybe North American felt they did, too, but you have to look, I believe if you're familiar with the situation and have worked with it some time prior to that, you

have to look with a jaundiced eye at limitations which come through as a result of the system not working right. You should make every effort to have the real limits before flight and not change them to conform during flight. We all recognize that if it had been a case of just trying to limp along long enough that certainly we'd run as high as you have to.

CUNNINGHAM that had it hit 200, I wasn't going to be concerned about it. At that point in the game, I would have let it run right on as high as it could have before deorbit. That fairly well covers the condenser exhaust situation, I think. The fuel cell indicator switch - as I say, we checked it back and forth generally in conjunction with checking the fuel cell performance with, again with the current EPS. The indicator switch itself, whenever we had a problem we've got, we were faced with the ganged inputs to the master alarm once more. We used to have nine inputs to the fuel cell lights; now we have five, but at any rate, when one parameter triggers the fuel cell light, you are not going to get a second caution and warning light coming on for fuel cells. Therefore, the standard procedure is to monitor the one that has the indication. We were fortunate; we never had more than one fuel cell that required this. We monitored fuel cell 2 almost continuously and not from any undue concern as much as just from

the fact that that was the only way we could really verify fuel cell 2 after the light was triggered.

Purging is an interesting topic for discussion here because purging was changed in real time in the flight plan. I think this is the way to do it. There is a nominal purging time line that you can have for a spec purity of the reactants. It turns out that for oxygen it's not too terribly flexible; but for hydrogen, it's a very strong function of the purity of the hydrogen that you're getting. Since we had apparently much better hydrogen than the spec, we were able to relax the purging of the hydrogen. It's also very worthwhile because apparently it was expected that we would have about 6 percent remaining on the hydrogen, and we really ended up with about 14 percent, I think. Donn, I wrote that down some place. It looks like about 14 percent.

EISELE It's either 12 or 14 percent on the meter.

CUNNINGHAM Yes.

EISELE It's right in that region. We had plenty.

CUNNINGHAM Hydrogen is always going to be probably the most critical of the reactants. We finished up with 14 percent of hydrogen, and so it's well that we did schedule hydrogen purges in real time. The purges themselves are a nuisance in one way, and it's the same thing that has bearing on other things that go on on the flight. There's a lot of things going on at the same time. These are relatively time-critical, and you're supposed to purge hydrogen, for example 80 seconds, and you want to purge one fuel cell at a time. You go ahead, and you purge fuel cell 1. You check the clock before you get the time to turn fuel cell 1 off. If something else has interferred, you're taking an update. When you get through with the update, you look back. Fuel cell 1 has already been running more than 80 seconds, and you turn it off, and you get fuel cell 2 on. It takes a lot of concentration and ignoring anything else that is going on in order to keep these things coming out right. I would bet that there weren't a half a dozen purges that went on on this flight that lasted the spec time, and some of them you

know were only a few seconds over. Early in the flight, I felt very bad about it when it looked like we were going to be close on hydrogen. I felt very bad about it if I ended up taking - instead of 4 minutes for our purge cell, ended up taking six for example. I felt like I had wasted 2 minutes of hydrogen. So it is a problem; and for oxygen, it's not too critical because of the consumables, but you purge those for 2 minutes which allows you a little bit longer time to get distracted. I couldn't stress more that when you get down to this part of the systems work, it's well to let a guy go to work on that problem, and just don't bother him at all until the thing is over. Another thing that would be very useful is a timer. I had suggested this prior to the flight. We tried it out in the simulator, and because the simulation is not quite like flight in these respects, you never do purge fuel cells because the performance never did degrade. The simulator is not realistic enough here as far as keeping you moving along with this kind of a time line. We found that we weren't using the

timer in the simulator. In flight, my general impression was we could have used it. What do you think?

EISELE It would have been very helpful.

CUNNINGHAM Yes.

EISELE Because there are so many little things that you do not only purges, but little things that you may start and then want to come back to and monitor a few minutes later. But you'll forget to come back a few minutes later because you'll in the meantime get engrossed in something else.

REP Are you talking about a digital type event timer?

EISELE No, an alarm clock.

CUNNINGHAM This was like a cooking thing.

EISELE Something you can wind for a few minutes and let it climb down and ring a bell and let it remind you that you better go look at your gimbal angles or your fuel cell purge or whatever.

CUNNINGHAM The one that I had Pete King bought from Joske's or something for four bucks. It was a little round one like a pocket watch and very flat, and it was accurate to within about 2 minutes

over 30 minutes which is pretty useful. You just crank it up and wait for it, and it would buzz when you got through. I really think we could have used it in flight. You mentioned a digital timer, Deke, and I really feel like in the right couch - I think, I covered that in the room with you one time - a DET would really be good someplace there where the guy on the right couch could see it. I felt like - you might expand on this, Donn - we didn't really make much use of the DET and MET in the lower equipment bay.

EISELE No, the only time they used the DET was during rendezvous. We were down there most of the time. I used the MET quite frequently in the day passes because the bright sunlight would obliterate the one on the MDC. When I wanted to know what time it was, I would lean over and look at the one on the LEB which was not blanked out.

CUNNINGHAM We used that one also to check the accuracy of the one on the MDC because that one seemed to run right on; MDC would lose a couple of seconds.

EISELE You'd lose a little time now and then.

CUNNINGHAM Okay.

EISELE Well, I think the MET down there is valuable; I'm not sure about the -

CUNNINGHAM At any rate, purging is no problem. You could definitely see an improvement in the fuel cell performance immediately after; almost during it, you can see it come up a little bit. The hydrogen purge naturally always triggered the master alarm. The oxygen purge when you were in drifting flight configuration generally would not trigger it. When you were powered up, the oxygen purge would trigger the master alarm just as expected. The reactants, switches, and indicators - the CRYO's themselves: I might comment that the hydrogen pressures and the oxygen pressures seem to hang in the lower half of the green areas throughout. Now this was expected because of a marked difference between actual pressures and what we were reading on our meters. It seems that we are living here with meters that are less accurate than I would like to have, and in some cases, this inaccuracy even runs into contradictions or complications with the caution and warning

limits. In some cases, the nominal range of operation gets you closer or even possibly exceeds caution and warning trigger limit as for example, the CRYO tank venting. At one time, flight operations director was much concerned with the CRYO tank venting, and it turns out that the master alarms for the CRYO tank high pressures doesn't even trigger until after you exceed by a very slight amount the venting pressures. We had one very definite problem associated with the reactants switches, and that was the oxygen fans. Early in the flight, we had an AC bus 1 fail. I reset it; it went into the log as an anomaly. Sometime later, we had and AC bus 1 and an AC bus 2 fail simultaneously, and this was an anomaly for a while. I can't say too much about the way the ground took care of this one and troubleshot it. In real fast time, we were somewhat concerned about it, naturally. The ground took a look at all the data and correlated very nicely the oxygen fans in their AUTO position. They both kicked off at the same time, triggered by a pressure switch, and it turned out that this transient

load loss on the AC bus was allowing the AC buses to hit an overvoltage of above 130, and it kicked the inverters off the bus, and we had a bad situation staring us in the face. The procedure they recommended to get around this worked successfully throughout the flight. That was that we went to O_2 1 fans to the AUTO position and the O_2 tank 2 fans to the OFF position; and at specified times, in real time, we would turn the fans to the ON position in tank 2 and allow the mixing to go on. This was aimed not so much at never having the glitch occur again as it was at making sure that if the glitch did occur, it would only affect one bus, and I think that is probably a good head. As it turns out, we never got the transient any more. There was a time when we would have both fans ON, but one was in the ON position, and if the AUTO position on tank 1 had kicked off, we still wouldn't have gotten probably the transient. During burns, both fans were in the OFF position.

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SPACE ADMINISTRATION

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APOLLO VII TECHNICAL DEBRIEFING Part II (U)

PREPARED BY

MISSION OPERATIONS BRANCH
FLIGHT CREW SUPPORT DIVISION

GROUP 4
Downgraded at 3 year Intervals; declassified after 12 years.

CLASSIFIED DOCUMENT - TITLE UNCLASSIFIED

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
OCTOBER 27, 1968

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SCHIRRA Yes.

2.24 SECO

SCHIRRA SECO was nominal as far as I could tell from the time line; that's nothing to worry about.

2.25 Orbital GO/NO-GO

SCHIRRA We got orbital GO/NO-GO quite fast, and the most satisfying thing was S-IVB safing information, safe for destruction.

EISELE Very quickly.

2.26 Communications

SCHIRRA We had all the COMM that we needed. COMM was sufficient but for the lack of mode 4 call out. That would have been critical if we had had an early SECO and we didn't know it. When you get down to it, we had very little complication for orbital insertion. That COMM must be straightened out. That's a big anomaly which is the kind of thing that we should have on the black board. Insertion COMM was not GO.

EISELE To have COMM, all you have to do is turn your S-band up.

SCHIRRA I knew I had it up. It says so in the log.

EISELE When did you get your S-band up?

SCHIRRA — When I couldn't hear them. I didn't hear "Roger" for a couple of calls, so I turned the S-band up. They heard me say S-band up.

EISELE — When we talk of listing things up there, I personally don't think that this is a constraint on Apollo 8, on the C' mission.

SCHIRRA — I very much do. The communications at SECO is necessary. If you don't hear a SECO, it is hairy. You have got to have a GO/NO-GO for mode 4.

EISELE — That's just during the launch period.

SCHIRRA — That is true. It's a constraint for another launch, and the next one happens to be Apollo 8.

EISELE — Not necessarily for C'; that's what I'm getting at.

SCHIRRA — Yes, the next Apollo launch should have communications into orbit.

EISELE — That's right.

CUNNINGHAM — The next Apollo launch is either the C' mission or the C mission again.

SCHIRRA — Then it's a constraint. Communications were not satisfactory during boost. That's what I'm trying to say. Maybe there was a procedural error. The call after we acknowledged by

selecting the appropriate control made -- it may be we're unearthing a problem.

CUNNINGHAM — We have always been concerned about the flame pattern affecting the antenna characteristic.

SCHIRRA — Why didn't that happen in the Mercury and Gemini?

CUNNINGHAM — I don't know. They had pretty small flame patterns compared to this.

SCHIRRA — Not at SECO. It was enough to covert the whole sky from down range. I'm not about to testify to the size of the flame pattern, that communications had better be improved. We can't afford not to have communications through SECO. I guess that's my error rather than yours, Walt.

CUNNINGHAM — Do you want to write that up here?

SCHIRRA — Yes. I think you ought to write EMS up there also while you are standing at the board. That was a constraint, and everybody knows it.

2.27 Control and Displays

SCHIRRA — Controls and displays were satisfactory.

2.28 Crew Comfort

SCHIRRA — Crew comfort was satisfactory.

SCHIRRA That was a rush, rush, and we locked out.

EISELE Yes, we somehow got off the time line there, and we had to kind of squeeze it in there.

SCHIRRA We had a gimbal lock. The first time through, we changed seats.

EISELE Burn number 3 was a ditty.

SCHIRRA Burn number 3 came up down the road from that test, and we had lots of things going wrong.

REP Is that what went wrong?

SCHIRRA Yes.

REP Okay.

SCHIRRA We had a gimbal lock, and we changed back to our original couch configuration.

EISELE We had to hustle.

SCHIRRA I wanted you down in the IEB doing the sighting. Not that I felt Walt couldn't do it yet, but you had had more experience down there than Walt for two burns. We briefed that if we ever got in trouble, we would go back to our original seat configuration. No one was offended; we raced right through it. Walt was more experienced in racing us through the checklist, and I

knew what I wanted to do in my seat. As it was, we checked out and made it. That was the one place where we came close to blowing the time line.

EISELE Yes, that was pretty rough.

SCHIRRA We had given up on the White Sands rendezvous radar test, but the ground said go ahead and try it anyway. We had to throw it into attitude. I remember I was flying around pretty fast there.

CUNNINGHAM In fact, it was on the real time flight plan we put in on the next rev. It wasn't intended to be there until the next trip.

SCHIRRA That was when we were getting a little speedy.

EISELE There was a change in the flight plan; they moved that in, sandwiched it into somewhere else. And that is what threw us a little behind, that plus the gimbal lock. But we did make it and got a good test. All is well that ends well. They did very well.

SCHIRRA I would like to say one thing I didn't say in real time. I feel like I did in Gemini VI with that rendezvous radar done for that next crew, like Gordo and Pete did for us on Gemini VI.

3.0 ORBITAL OPERATIONS

3.1 Insertion Through COAS Calibration

3.1.1 CSM/S-IVB Orbital Operations

SCHIRRA — CSM/S-IVB orbital operations went exactly as predicted.

EISELE — I think the time line and the procedures we followed - the sequence of doing things - went almost identically to what we rehearsed in the mockup and simulators.

CUNNINGHAM — We followed very closely the detailed first six revs checklist.

SCHIRRA — One thing we should get into is this little deal here. We followed this religiously. We smuggled it on board as part of the checklist.

CUNNINGHAM — Yes.

SCHIRRA — He passed it to me, and I had it over here on my side all the time to keep track of any glitches. It was very detailed, like what you unstow, when and other things like that.

CUNNINGHAM — It should have been part of the flight plan.

SCHIRRA — Here are all the cameras you have to have up here. There are some numbers I recorded on the launch vehicle propellant pressures. I gave these to the ground, and I don't know if they

should be recorded again. They're in this thing in case they need them. That was for four different times. They change. I was surprised. Fuel pressure went up, and the O_2 pressure went up. Before I go on, we were scheduled for a debriefing on the S-IVB time line real late in the game. We have been over than many times. I really don't think you need all these booster briefings.

REP — I think the Marshall people requested it.

3.1.2 S-IVB Safing

SCHIRRA — We did mention on yesterday's tape that I was very much concerned about GO/NO-GO on S-IVB safing. That was a very warm feeling, knowing that it was safe. I perspire at the thought of going one more rev with that thing. It was one less thing hanging on my mind on the first rev.

3.1.3 S-IVB Take-Over Demonstration

SCHIRRA — Demonstration was exactly as we planned it, and I appreciated the rapid response of everybody cutting that time line in half because it was too long the first time we did it. That's one of the few rapid responses we had with DTO. They responded to that almost immediately in

Huntsville. The S-IVB flew better than in simulation. I prefer it to go that way than I would the other way.

3.1.4 Return to S-IVB Auto Control

SCHIRRA Return S-IVB automatic control, no problem.

3.1.5 Separation Transposition and Simulated Docking

SCHIRRA This was a whole new world to me, and I guess that was one of the big things we discussed and lost. I talked to almost all the command pilots out there on the horn. We really concentrated on getting on that Langley simulator. That's the only device that I know of that will do that. I suggest that they don't try to pitch around, particularly if they get faster than 5 degrees per second. I think that's a big mistake.

EISELE There's no big rush about getting around.

SCHIRRA I opened at 1 foot per second, and then I descended to one tenth of a foot per second. Then I pitched between two and half and 3 degrees per second. It's still fast, but you get kind of anxious to see what is going on back there. Donn saw it right away and started saying "WOW, what a sight!" You don't know what's going on. I didn't know if it was going to come down on

my back like a big train. When I looked out, all I could see was S-IVB all over the place. That one panel was in the way, which discouraged me from going in too close. That was the panel that I couldn't see when I came in. I aligned to the docking target, and we came in close, as the film will show.

CUNNINGHAM I took that picture, and I didn't know we were that close.

SCHIRRA We were in there. I was afraid I was losing sight of that one SLA panel. It was catty wampus. I think it is a good decision to have the SLA panels go; that's the only way to do it. Get rid of those things.

EISELE They have got to go out 30 degrees before they go.

CUNNINGHAM I wouldn't guarantee that that was 30 degrees.

EISELE Maybe 20 or 25 degrees.

SCHIRRA Those pictures are invaluable on that basis. That is a problem. I really didn't feel comfortable with this machine. It felt like a big, big truck. Another analogy I've used, was first time I had a boat, a trailer, or a house trailer behind my car. I was really scared to

back that car up. I had to back the car up countless times before it never bothered me. That's the kind of analogy you get when you first see that S-IVB out there. It's awful big, and it is very difficult to maneuver the command module that precisely. We have a light command service module compared to the rest of the mission. I can only recommend the device we have at Langley for training crews. I wish I had gone up there. I would have known more about it.

3.1.6 SLA Photography

SCHIRRA — SLA photography is evident. We don't need to talk about that now. I see we've got our pictures back.

CUNNINGHAM — It turns out that the SLA photography was slightly hampered by the window view.

SCHIRRA — One thing that bothered me was the field of view in that window.

CUNNINGHAM — I think you were up a little high on that maneuver in relation to your window.

EISELE — Yes, you're right.

SCHIRRA — I needed to roll in order to line up.

EISELE — Yes, that's right.

SCHIRRA I needed to roll to get both windows lined up in the same place.

CUNNINGHAM That's right. The sequence camera, when it's mounted in the bracket is pointing out a nice unused hole down there in the rendezvous window. It did not tend to line up if you moved off a little.

SCHIRRA I would like to go - back to that transposition. The mode I used was PULSE in roll and yaw and ACCEL COMMAND in pitch. I think everybody should use that one. Rather than RATE COMMAND in yaw and roll and whatever in pitch. That's the cheapest way to get around. Once you get around, you can start tightening up as you start getting ready to translate; then you might want to use RATE COMMAND for the three attitudes. I do think you need something to stabilize attitude when you translate. You could use DAP pulsively. Jet priority logic on subsequent SC may help the problem.

3.1.7 RCS Phasing

SCHIRRA We did the RCS phasing with the service module RCS separation. That thing was less than 10 feet per second. It was a simple maneuver, and it

went off quite well. We took residuals out, didn't we?

EISELE — We didn't have any.

CUNNINGHAM — You were burning 7 feet. You burned 7 feet on the P47, didn't you?

SCHIRRA — We used P47 for venting, too, and it worked out quite well.

CUNNINGHAM — It was significant. I was surprised. We built up how much? 25?

SCHIRRA — 26 feet per second on the DELTA-V counter. That had a bias that is calibrated and has been reported over a period of time.

3.1.8 CSM Systems Checkout

EISELE — You were out of here when we did that, Walt. We have already gone through that.

3.1.9 Sextant Calibration Test

REP — Donn's got a NAV COAS calibration.

3.1.11 S-IVB Ventilation

EISELE — We noted that when I came in close at the point were the S-IVB was stable, I could see little vent pipes I never even knew about up there in one of the SLA panels. The one just south of the target adapter was squirting stuff.

CUNNINGHAM — Yes. I want to make note of the fact that we did see trash inside there. It looked like part of that charge stuff there. There were bits and pieces of that floating around. There was a lot of it. There's nothing really to talk about on ventilation, ice clouds, and vapors. They were just there. That wouldn't deter me from pulling in to take the LM. I definitely wouldn't want the S-IVB to start moving around. The CSM isn't that spry of a vehicle that you could go in there and fight some other system and try to fly as well if the S-IVB were moving.

3.2 Rendezvous

SCHIRRA — Line of sight control was very good on this particular flight. We had real good luck with it. I was a little worried about the fact that we had what I would call a hidden TPI. We didn't see the target. I had no confidence in the

rendezvous because of that. Everything worked nominally. The plot was beautiful; time was good. Everything looked like it was good. The midcourses justified the solutions. We did have to take one backup that Walt had to justify the midcourse.

CUNNINGHAM We essentially burned the backup ...

EISELE We burned the backup rather than the G&N because I felt the G&N was too big a number.

SCHIRRA We had - out of plane if I remember right.

CUNNINGHAM A little less than half out of plane.

EISELE We did all maneuvers to the burn attitude for TPI, and I suggested taking out half of the out of plane which we did ...

SCHIRRA I'd say the whole run worked well, but in real time I was scared to death.

EISELE I just had the feeling that we could go ahead and do the TPI on faith basically, and we would know later whether we were going to make it or not. I figured we'd see the target sooner or later as we got up close; then we would know whether we were going to hack it.

SCHIRRA The real threat was when I finally did acquire the target visually. (It was after midcourse.)

We saw the lights blinking, and that's a nice feeling. I hadn't seen it before because I wasn't aimed.

EISELE The next crisis was whether or not we were going to come into daylight before we got to it.

SCHIRRA Yes.

EISELE We figured we did.

SCHIRRA The line-of-sight control was no great task. I didn't do much dittering because I was afraid to ditter with this big boat. It's too expensive when you set up a rate and have to take it back out again. I remember I made one remark that I was happy about the fact that we had a theta of about 130 or 135 degrees, and I said "that's perfect." Right on the mark.

3.2.7 Braking

SCHIRRA — Braking was a complete nightmare with no ranging whatsoever. To judge the diameter of the S-IVB, all you can use is a good number. Anything else is arbitrary. The length of it, the SLA's diameter are not good. It was so bright that you get overtones of light across the COAS, and you're not sure if it's 1 degree. I believe I called out 1 degree, and it was something like eight tenths of a degree. We braked a little bit early, all the way in. This is an awesome target.

CUNNINGHAM — It looked about right from my side.

EISELE — I didn't have any ...

SCHIRRA — You didn't have an index, but you could feel it.

EISELE — It felt like we were coming in pretty good, a little slow in the end.

SCHIRRA — The interesting part of this was that this is a very big target. You take a little LM up there with only an ascent stage; that's a very small target. My point is that we have got to validate a ranging device for braking, because the LM is awfully small. You have to have a tool on board to range that LM for braking.

You have the VHF ranging, and you have the LM radar. These are still available and shouldn't necessarily fail. My anticipation is that if command module active rendezvous is required because of running low on fuel in the LM rather than because of a PGNS radar failure, then you can use the LM's radar as a ranging device. This helps fantastically on braking.

3.2.8 Rendezvous Navigation

SCHIRRA You covered rendezvous with navigation, didn't you, Donn?

EISELE Yes, I covered that. I don't recall the exact number of marks. All that should be on the tape. Generally, DELTA-R and DELTA-V were small and appropriate because we had such a fine set up to begin with. Phil Shaffer and the flight controllers were right down the slot on that.

SCHIRRA It was really good.

EISELE We had a very good state vector there. It was in the same condition all the way.

SCHIRRA It really meant that the onboard computer agreed with the ground solution.

EISELE The auto optics tracking of the target became a little spastic there as we got in closer to the target after TPI.

SCHIRRA I would like to go back to braking again. We asked for a ranging device like a stadimeter. It fell down the crack because people thought their visual optics system was good enough. There was one in work, and I recommend that that be reopened, particularly for a small target the size of a LM. There is a device in the shop that can be made usable for the LM, not the one that was unsolicited from the Coast Guard. This one was like the sextant I used in Gemini VI with Tom Stafford. It is big and bulky, but it's good. For example, in Houston we worked with a rendezvous device. The darn target had an apparent size of 10 000 feet. We tried that 10 000 foot mark, and I made every rendezvous with just one range reading. You get super-confident in that onboard system. The other thing we made note of yesterday that disturbed me no end, was earlier Donn was not able to train on checking the state vector data display against the sextant display of the horizon

enroute to TPI. I feel that should be done. It fell out of my time line because there was no way you could practice doing it. I did ask you to do it a long time ago, and that was something you could rehearse doing. I think that's more important than any backup data point because you have to validate that statement somehow.

EISELE I know I got it put back in the update form, and we got it from that. It worked just the way I thought it would. Since we had not trained to do it, we would not get on doing it.

SCHIRRA It was too late before I discovered you weren't doing it. We discovered this in one of the sims. I was surprised it fell down in the crack. I didn't get with you enough earlier to explain to you how important that was. I didn't take advantage of my experience there. That was a goof on my part.

3.2.9 Formation

SCHIRRA Formation flight is just about the same as transition and docking. It's an expensive mode in the command module. I have heard people talk about the command module doing the docking with the LM. I think you will find it is much easier

to use the LM for docking with the command module. It was just too big to move around. You still have a big load on that command module, but if that is a requirement again, I say spend a lot of time at Langley. We're not lacking for the tools to practice. We don't have a tool in Houston to fly command module active, but we have a tool for flying LM active. That is the only tip I would like to pass on.

3.2.10 Final Separation Burn

SCHIRRA Final separation burn is the big burn. I guess that is what we're talking about here.

EISELE One foot per second.

SCHIRRA Oh, this is back in rendezvous. That did concern me initially because I didn't want to be in a position where I might close in again on the target. As it turned out, we had effected the rendezvous from below and stayed below it inertially. We got to the point where we were going to separate. We separated from below it - minus - as we backed away from it which is what we're supposed to do. The rendezvous was completed with a so-called whifferdil. We went around the thing up at the top and then had to

go by the thing and then do the separation burn. As it turned out, we were in the right place. You definitely don't want to burn towards the vehicle zone.

3.2.11 S-IVB Activity

SCHIRRA — It was moving at rather high rates, and that was logged on the film.

3.3 Postrendezvous Through Deorbit

SCHIRRA — We went through the first three items up to the WSMR. I think that one is self-explanatory; it went off very well.

It felt real good to know that thing tracked out, and I think I ought to bring that up during the press conference; we felt very warm about it, and we had asked for that test to be done. It was almost dropped, but people responded and got the gear ready for us, and we worked it.

3.3.5 Sextant Tracking

EISELE — We tracked landmarks and stars and everything went fine. Later on, we talk about the mid-course NAV.

3.3.6 SPS Burn Number 3

SCHIRRA — Burn number 3 was just like burn number 1 and 2; it was very nominal. No problems whatsoever with it.

EISELE — I'd like to mention that burn 3 was an SCS burn with G&N monitoring, and the residuals were very small. I came away with the feeling that for anything except an extremely long curve burn such as lunar orbit insertion, that you're probably just as well off to do them in SCS because it is right down the wire. Cutoff was just within a couple feet a second.

SCHIRRA — Cuts off better than the G&C does.

EISELE [redacted]ane errors were very small also.

3.3.7 Slosh Damping Test

SCHIRRA There is no problem with slosh damping. After each major burn, we found a big puddle of water on the aft bulkhead, and it stayed there. It didn't go all over the cockpit; that is the best slosh damping test we ever had. And there is the answer to slosh damping. There is no problem.

CUNNINGHAM We never saw any evidence of any kind of motion you could attribute to fuel sloshing around after any SPS burn or RCS maneuver.

EISELE This puddle of water didn't even move. There was only one area that it came from.

CUNNINGHAM Yes, I think so, too. We did the tests that were in our burn schedule and flight plans, and we never noticed a thing from it.

3.3.8 ECS Radiator Test

CUNNINGHAM Let's see, the next one is the SCS radiator test. I think it was a big surprise there initially. Donn started the thing out and found out that we were in minimum deadband - the 4 degree deadband, and the machine was

kicking off thrusters like mad. Wally had already seen that we hadn't pegged what we call perigee torque yet.

SCHIRRA I remember you sitting in there for a while, and you were getting real worried saying, "My flight control technique, it's terrible, what is this?"

CUNNINGHAM When Donn got out, I relieved him. Donn had eventually come to the conclusion that we were better off doing it in pulse in all three axes, instead of holding pitch and yaw and rate command. I got in there, and we were holding it in pulse. I must have gotten in there just as we started through perigee, and we were supposed to be holding within 5 degrees, and we ended up 10 degrees off.

EISELE I said, "This is your crazy DTO, you better fly it."

CUNNINGHAM That's right; he washed his hands of it; he did.

EISELE I got out, got out, got out of there, went down in the LEB and blew my nose for a couple of hours. I was flying along and found out that the pulse was better than the attitude hold, and I was tweeking it in, holding within a

couple of degrees, you know, just going along just fine, and then Walt got in. Apparently, right about then was when we started getting perigee because Walt started hollering about the thing wouldn't stay where it was supposed to. I looked, and he was 10 degrees off.

CUNNINGHAM In pitch and yaw.

EISELE I wondered what has he been doing wrong, so I got in and tried it again. After a while, it was doing the same thing. It seemed to be intermittent.

CUNNINGHAM We were 90 degrees out of plane for the test.

EISELE Yes, which is the worst case for the perigee torque business. And we were trying to maintain an ORB rate roll, which meant that we were coupling up between pitch and yaw all the time. I guess we got that comment on tape about how many pulses it was taking when you were in attitude hold.

CUNNINGHAM Yes, we counted them, and it was a fierce number per minute in attitude hold.

SCHIRRA That is where we became concerned about these tight control modes.

EISELE And then we went to all pulse modes, manual pulse mode, and the number dropped by a factor of ten, at least.

CUNNINGHAM We finally finished the test, and it was a four and one half hour test. It turned out we were on the nominal amount of fuel which had been alloted for it, which was a lot more than Donn and I had figured we could do it for.

SCHIRRA I remember. You all got concerned about it, and I did take over towards the end because I wanted to find out what the control problem was.

CUNNINGHAM Yes, you did relieve us for about an hour there.

SCHIRRA That is when we discovered the perigee kick, because I started calling up 82 and 83 to find out what kind of perigee we had. 83 wasn't any good since we were out of plane, so we called up 82, and I found out we were going through perigee when all these problems came up.

CUNNINGHAM One other thing, we did do the coarse align. - because of a misloading on the DAP load. I loaded the DAP load into P30 the first time through. It looked like we were about ready to blow the thing on that rev, and Donn came to

our rescue and coarse aligned us. He went through P30 and loaded it right and did a coarse align to the right attitude.

EISELE Yes, we didn't have a night pass to do a fine align, so we just bought the coarse align. We really lucked out on that because later on, when we coarse aligned to the subsequent

3.3.9 Midcourse Navigation

SCHIRRA — We are now on the area of course NAV.

EISELE — I was thinking it was some point over Guaymas, I don't remember what it was now.

SCHIRRA — What's this mid-course NAV consist of?

EISELE — This is P23.

SCHIRRA — The one on the DTC.

EISELE — The midcourse NAV program was set up to do marks using a star and earth horizon technique. And we found on the first and only attempt at this, that it didn't work very well. The main reason is that the earth horizon is a fuzzy kind of a thing; it does not appear as if there's any precise lines or delineations that you could use reliably as an index for a mark. This is true when you look at it in the sextant because of the magnification. When you look at the air glow or the earth horizon at certain times, such as near sunset and sunrise, you do see some very distinct banding if you are looking at it through the window or through the telescope. Again, that only happens at certain times of the day, at sunset and sunrise, and only in the area that is pretty close to where the sun is going

to be coming through the horizon. At other times, such as at night, the horizon is just kind of a muddy brown and fuzzy looking. During the day, if you look off away from the horizon toward the sun you don't see much of a well-defined horizon. So this test did not work out at all. I just could not pick out anything in the airglow. I could not pick out what looked like a horizon at all. And, also, it turned out that the stars - this was a daylight type of thing - had given us an attitude to fly some shaft and trunnion angles. I put in the optics and no star appeared in the sextant, so apparently the angles were a little bit off. I didn't know how in the world I was ever going to get that star in there. I thought about it later, and perhaps if I had enough hands and was swift enough, I might be able to do a P52 and pull the star in with AUTO optics. Then I would have to hold it there manually while I reselected the P23 program. It didn't seem like it was worthwhile because we had a horizon problem. We reported this to the ground, and they apparently agreed because there was no more mention of the star-to-horizon technique.

Later on in the flight we did do a P23 using a lunar landmark and a star, that worked out quite well, I thought. It was very easy to do. The moon was in a phase where it was getting close to the sun; that is, the final phase of the moon. We picked up landmark 5 very readily because of the low sun angle on that part of the moon. We were able to use lunar landmark 5 and I don't remember what star it was, but we pulled one star in there and I got a couple of marks on it. I think only one of them got down on the data, and I did hear that they were satisfied with the results.

CUNNINGHAM We might mention that the three of us took a look at it, and it was a very easy control task. I had never tried anything like that before.

EISELE Yes. Also, we spent considerable time at various periods examining that air glow and the earth horizon out the window and through the optics. None of us could make any sense of it, as far as being able to pick out anything repeatable to use as a reference.

CUNNINGHAM The only way that you could possibly get a fix was to watch a star occult as it went through.

EISELE It was pretty hard to tell exactly where it occulted.

CUNNINGHAM Yes, it started blinking right down at the bottom. You were never really sure when it disappeared.

EISELE Well, I think the problem is that P23 has applications to the translunar flight. Normally you would not be using it anyway until you were several thousand miles from the earth. I am sure at that distance that the horizon, the earth horizon, or the earth landmarks would appear quite different from what they do at 100 miles up.

CUNNINGHAM Does that handle mid-course now?

EISELE Yes, I think so.

3.3.10 Cryogenic Stratification Test

CUNNINGHAM Okay, the next item of discussion is a cryogenic stratification test. This was a test we performed at three different quantities in the hydrogen and the oxygen tanks during the flight. We did end up performing it three times with the hydrogen and only twice with the oxygen. The results are in the DTO book, and they will be passed on. I did update the procedure in flight with the pressures at which the hydrogen tanks were really

cycling back and forth. Hydrogen tank 1 was running between 228 to 248 psi, and hydrogen tank 2 between 237 and 255. I modified the procedure to reflect these numbers. The data showed little or no stratification. In the first hydrogen test the pressure may have changed after the heaters were turned off and the fans were turned on. On the oxygen stratification test there was a very definite decrease in pressure when the fans were turned on, which I would have interpreted as having stratification present. The second time the test was run the results indicated to me no stratification in either oxygen or hydrogen. This was nominally at the 60 percent level. At one time, on the last day of the flight, or during the night preceeding the last day of the flight, the hydrogen stratification test was run. It showed results similar to the earlier test, essentially no stratification.

3.3.11 SPS Burn 4

CUNNINGHAM — SPS burn 4, I will only say that the system worked as planned. On this minimum impulse burn, though, we did use, I believe, our first 2-jet ullage. We ullaged for 20 seconds and

selected the quads for ullage appropriately after being advised from the ground which quads were most desirable to reduce the fuel in. The engine worked normally, and the burn time was about .54 seconds, maybe 17 feet per second, something like that. We were still impressed by the fact that the engine, even though it was burning only half a second, came up and slapped you in the back just like all the other starts; and it was over immediately. Ball valves, all four of them flipped, had time enough to flip completely open and closed again. Essentially, I don't feel like there is anything significant to report other than it was a normal SPS burn.

3.3.12 SPS Cold Soak

CUNNINGHAM — The SPS cold soak test was the one where we were to monitor the oxidizer distribution line temperatures and the fuel distribution line temperatures. We monitored SPS propellant tank temperatures as they were labeled on MDC 3 and did the cold soak attitude for 3 hours. The cold soak attitude was then taken up. The procedure involved turning the heaters on at 45 degrees F and off at 65 degrees F. The temperature never changed, we neve

activated the switch, and, as a matter of fact, the propellant tank temperatures ran between 68 and 70 the entire flight. I never felt like the heaters were necessary for controlling the line temperature. On ground request they were turned on several times, based on another SPS temperature which was down by the injector valves or something. The ground did have another temperature that they were interested in. When we turned the heaters on, apparently it satisfied them that the temperature in concern rose. There was one other time, later in the flight, when the heaters were tested just for operation. I had proposed we do this early, and the ground had some reservations about it. Later on we operated for 2 hours and ran a 6-hour test, 2 hours with line heater in position A, and then another 4 hours with it in A/B, and to my knowledge the temperature never changed. It was finished up on Donn's watch.

EISELE Yes, I think it got up to 72 degrees and just sat there. I guess the point is, the SPS propellant and line temperatures seemed to be very stable and always stayed within the normal range. We

never, at any time during the whole flight, had to turn on those heaters to keep it within that range. There was never any problem at all, and the so-called cold soak test really didn't get it very cold at all. It still was above the minimum.

CUNNINGHAM The significant point is that we never required them.

EISELE No problem.

CUNNINGHAM I know where I got off. Bill Poage labeled it cold soak.

3.3.13 SPS Burn #5

SCHIRRA All attitudes were great. We started off the burn as a G&N burn, and at 30 seconds, we were scheduled to flip into GDC. The only variable that came up was a new way of doing burn 5, and that was a big mistake. The mistake was that the ground's way of doing burn 5 was to add 100 feet per second so we could shut off the burn with a hundred feet per second to go on the DELTA-V counter, with the thrust normal switches A and B OFF. This is to check the ball valves OFF and terminate the burn that way. We should have had simulated burn 5 with Houston on the simulator; we didn't do it that way. I'd never heard about it prior to this event. I negotiated them down to 50 feet per second, and Walt was trying to talk me into going down to 20 feet per second on top of the scheduled burn. The surprise was that the burn itself was perfectly normal. The rate needles were never 5.5; the error needles were never displaced more than a degree. It was easy to control; it would often roll about 4 or 5 degrees, but that's nothing; that's typical. It's just that there

is no real roll control in MTVC, just the stick, rather the hand controller. You don't fight that; it is like the old retros in Gemini or Mercury. If you don't fight roll, pitch and yaw, they start to give you a little trouble. It didn't cup up; I just took out pitch and yaw, then I flipped roll in once in a while to bring it right back on. I was starting to watch the DELTA-V window, and I couldn't see it. The sun had started shafting in as we burned, and extinguished in that sense. Because of the bright light, I couldn't see anything on the DELTA-V counter. I started to reach up to kill it with my left hand; by that time the DELTA-V counter would normally cut it off. We overburned it by 50 feet per second; that's all there was to it. I heard it was an out-of-plane error, something like 15 feet per second. I don't remember that number showing up on the DSKY. The DSKY was running all the time to monitor the DELTA-V we got, not that I used it; this is to bookkeep. Also, the state vectors were up to date. We didn't see a number like that. I remember a very small number being out of plane.

I think Dave Scott was telling me he saw a big number and wondered if I'd diverged a little bit in yaw, so that number has got to be checked again. As I recall, residuals were very small in out-of-plane and up/down. The in-plane was 50 feet - well, wait a minute, the in-plane was in X-axis and was 48 feet per second, which was about 50 feet in actual burn direction. I can only say that you don't change a classic burn like that that late. It was changed right at the last minute. In the flight plan I had, maybe it does say the burn will be terminated by the A & B switches. That isn't the way we did it in simulation, and I did lots of burn 5's in simulation. Here it is right here, Deke; it says G&N ON plus switch OFF.

SLAYTON That's right; that's the way all flight plans had it. That's the way it is in the DTO.

SCHIRRA Yes, but I did these things, and no one caught me doing it the wrong way in all the simulations. I did it with Houston, and I didn't add a hundred feet per second to it when we did burn 5 with

Houston. Then all of a sudden, someone gets - That's why nobody agreed with it. It was a new thing.

SLAYTON I don't know how long it's been in the flight plan, but -

SCHIRRA That is not new, but adding a hundred feet per second to the burn was new.

SLAYTON I see.

SCHIRRA And then having me cut off a hundred feet per second error, that's the point. I understood what they were driving at, but I'd never done it that way. What got me was that I was prepared to do it that way, and I - we'd talked about it; we had enough lead time, but when I couldn't see the DELTA-V counter, evidently they didn't know I didn't know what velocity was left. If I'd known this, if it would've been brought to my attention by simulating it — which is how you learn all these things — I would have known then that I couldn't do it that way. You see my point. It was a surprise, and surprises are almost lethal. It could be lethal if that went off in the wrong direction. We always said if a burn wasn't going right, we'd stop a burn, except an

abort-to-orbit and a retroburn. So this broke that rule by putting in more than you're going to. We did this simulation without adding DELTA-V, that's what I am trying to get at. Regardless of the surprise on burn 5, it didn't hurt us so because all it did was knock off another 50 feet per second. That just drove us a little bit further in — back. We tilted the line of axes so that we had a little less than 30 degrees inclination, a smidgen less. I think it was called 30.08 degrees. Maybe we had 30.07. Since that was a very small error, it didn't hurt us one bit. But that was the one thing where a new technique, even though it was called for in the flight plan, disturbed the whole system. That's why I was objecting to it, because I'd never done it that way. I'd never terminated burn 5 by turning the switches OFF. Yet it was there. I just never caught it in simulation; no one caught me doing it wrong in simulation. With the instructors, we did burn 5's any number of times just here at KSC. They didn't catch me. And when I did it with Houston simulations — every burn we had here, by the way, was done with

Houston - they didn't catch it. They didn't throw in another extra DELTA-V, so that was why I was surprised. If I hadn't done burn 5 with them, then I wouldn't have argued with you. So they were thinking on their time that I didn't know about it, and that's the kind of stuff I don't want to have happen, that you shouldn't have happen. In the same light (I have to say this) we shouldn't be that iron bound to a burn, but the technique was - I'd never shut a burn off that that way. All our mode 4's I could shut off within 2 or 3 feet per second with those same switches; I trained for that. That's the way you shut off mode 4's because when you got 3000 feet up there, you could go from a hundred feet per second to 2300 feet per second. We were cutting those off right on the money. It's a technique we knew how to do in simulation, but not that burn; that's the whole point. I guess we'll just have to give the crew a briefing on that stuff.

SCHIRRA It worked, I'm not making it a major crisis; it wasn't.

Okay. Did you talk about window photography?

REP Right. We've gone over that.

SCHIRRA — I'm very concerned about those windows, I might add: I talked to Kennedy, and I talked to Healy about that today.

3.3.14 Passive Thermal Control Test

CUNNINGHAM — The passive thermal control test was the one which was run twice with slight variations. I guess what accounted for the 101 percent, among other things, was the fact that we did the pitch attitude.

EISELE — This was a test aimed at seeing what kind of cross coupling, or coning, you could get if you tried to set up a small roll rate with absolute zero rates in pitch and yaw. It was also to see how long it takes for that attitude to diverge in pitch and yaw in a coupling and whatever torques there were on the spacecraft. It seemed

to cone out pretty rapidly during this test. I really think that's because we are in an earth orbit, and even though you are up a couple of hundred miles you're still getting some torquing and some interference from the atmosphere.

CUNNINGHAM I show that the coning angle went out to about 4 or 5 degrees, didn't it?

EISELE Yes, in the course of that 20 minutes or so, it was about 4 or 5 degrees. The part of it we were concerned with and discussing was the fact that the test required a period of about 20 minutes in tight deadband prior to the time that you initiated this slow roll and went to free in pitch and yaw. The intent of this period, primarily, was to damp out the pitch and yaw rates. We had found out earlier in the flight, that the best way to damp out the rates was to use the manual pulse mode rather than rate damping. The tight deadband served no purpose other than to eat into the RCS fuel budget, and generate small rates in pitch and yaw, which we never did zero out. We tried to explain that to ground controllers and apparently it never was fully understood by the people responsible

for this DTO. So we went ahead and did it as programed and found that the coning was significant.

CUNNINGHAM I have a suggestion for the procedure. I think that one of the things they did was that they attempted to free the attitude hold just as they hit 200 miles going up.

EISELE Yes.

CUNNINGHAM And it would seem to me that after we made the suggestion, especially after the worry about perigee torquing, they would have attempted to have the test finished at 200 miles coming down.

EISELE Coming down, yes, and that would get you away from having to do a tight maneuver near perigee.

CUNNINGHAM That's right, they would have had better data, and less complications by outside torques.

EISELE Yes. Well, in retrospect, I don't think it was all that significant. It would have optimized the test a little more, but we did accomplish several things. We found there was some coning. I think it remains to be seen on translunar flights, where this maneuver might apply, whether or not you really do get any significant coning over that period.

CUNNINGHAM Yes, certainly.

EISELE The other aspect of the test, and they added on another part to it, was to do a slow pitch maneuver rather than a roll maneuver. We performed that in the same manner with the tight deadband for 20 minutes, and then went to free to do the pitch. I don't know if that turned out any better. I don't believe it did; we still had some crossed coupling in the other two axes.

3.3.15 Window Photography

CUNNINGHAM On the window photography, we took stills through the window, before S-IVB SEP. We took still shots of the window post-S-IVB SEP. I believe I focused on the window using S0368 film. We also took two shots during the disrupt time when Wally and I went to bed the night before deorbit. These are part of the data that's already in the photo lab. We took many pictures through the window focused at infinity in our normal course of events, so we made no special pictures to fill that part of the DTO. They wanted films of the window coating and degradation where we pitched 180, rolled 90, yawed 180; we declined to do them.

It was a rather purist approach to the thing. We believe we had significant data on the window degradation. We made many visual reports and tracked the degradation of the windows througout the flight. The degradation could have been studied a lot better had we not resulted in being in stable II after landing. The windows, except for the rendezvous windows, were vented between the panes, and we ended up with sea water getting in there and washing the panes.

EISELE In general, the rendezvous windows stayed essentially pure throughout the flight. The side windows degraded slowly, and the hatch window was the worst of all. It got a lot of condensation in it.

CUNNINGHAM I think we should make a point of the fact that there was a significant difference in window 1 and window 5. Window 1 was located next to the urine dump, and we were continually having little crystals settling on it.

EISELE It had a lot of crud on the outside of it - particles.

CUNNINGHAM In addition to having any other degradation on the window, we had these particles settling on it. I never did have any of those particles on my windows.

EISELE It never got over to window 5.

3.3.16 ECS Secondary Coolant Loop Test

EISELE The secondary coolant loop test was conducted at 183 hours and 40 minutes into the flight. We initiated the secondary coolant loop operation, checked on the primary coolant loop and ran for 3 hours at an essentially drifting flight power load. The secondary coolant loop operated absolutely as smoothly as possible throughout the entire test duration. At the end of 3 hours we powered up enough equipment to add about 400 watts to the load. We continued to let the temperature stabilize for an hour and a half and then ran another 3 hours, and it operated every bit as well. During that entire time I believe we utilized about 3 to 5 pounds of water in the waste water tank. Glycol evaporator OUT temperatures, the secondary loop, were maintained between 40 to 48 degrees Fahrenheit. The radiator OUT temperature was generally between 40 and a

little over 40 degrees and slightly over 50 degrees. I guess the key thing here is the fact that I felt the secondary coolant loop operated absolutely faultlessly. I would not like to lead to any false conclusions here, because the secondary evaporator did not dry out during this 7 and one half hour run. We should not imply that it was any better or any worse than the primary evaporator. The primary evaporator ran on numerous occasions for longer than 7 and one half hours without drying out and yet would still end up drying out at some time. So I don't know what kind of problem we had there with the drying out of the primary evaporator; we don't know for sure that the secondary evaporator isn't subject to the same thing. The DTO required a comment on the condition of the secondary cabin temperature valves. The secondary cabin temperature valves did stay in the MAX cool position throughout the test. Smooth test.

EISELE I thought you might make mention of the fact that we still don't think this is a very good system to fly with by itself. For example, if

you were having to make a long flight back from the moon or to the moon, the G&N system would not be cooled by it.

CUNNINGHAM — No, that's a significant point. The G&N system is not on it, but I stand considerably higher in my regards for the secondary coolant loop test.

EISELE — Yes, it does quite an adequate job of cooling everything else.

CUNNINGHAM — That's right, we operated it during the redundant component checks at one time; it operated for a period of about 15 minutes to an hour. During that period of time the primary radiator outlet temperature, which was operating also, went down from about 50 degrees all the way down to 10 degrees. It does a lot of cooling. We also utilized the secondary coolant loop for reentry. It was very satisfactory.

EISELE — It bypassed the radiators and used the water boiler in the secondary loop for entry.

3.3.17 SCS Backup Align

EISELE — The first surprise on this one was that the south set of stars were not sufficient. We found out that the south set stars were only visible during

the night pass for about 6 or 8 minutes, and we didn't think that was long enough to permit us to do a proper assessment of these backup alignment techniques. So we consulted with the ground; they came up with the north set of stars, Navi and Polaris. So we used those, and the test of them worked out very well. Wally maneuvered the spacecraft around to the approximate attitude on the IMU ball, and then I took over in the G&N station with the impulse controller. It was a rather difficult and tedious task to try to align the thing very precisely because you have to control all three axes simultaneously. What I attempted to do first was to take the key star, which was Navi, and put it on the 50 degree mark of the telescope's crosshair, and then go to attitude hold in pitch and roll. I figured that would hold it on the spot. Then I did a pure yaw maneuver to bring the other star on the line. Well, when I did that, I forgot that the SPS lets go of the attitude hold in all three axes anytime you break the hand controller out of the detent. So it didn't hold on that 50 degree mark, and I ended

up going back to pure pulse for all three axes. After numerous attempts to get both stars in exactly the right position, I finally settled for a condition where I had Polaris right on the line and Navi very close, but not quite right on that 50 degree mark. I tried it several times and finally settled for what I thought was the best feasible thing to do, so we coarse aligned the CDG at that time. Actually, Wally was holding the GDC align button and he released it when I said, "Mark." We took that as our alignment. We then flew back to the 0-0-0 angles on the GDC ball and made the comparison with the IMU which was also aligned for that purpose. We found that the error was on the order of a quarter of a degree, which I thought was pretty fantastic. I'm not sure whether we just lucked out or whether it's really that good. The point is, it's tedious and time consuming and uses some amount of RCS fuel, but it does work, and it works very well. I would not hesitate at all to use that for either an IMU or an SCS backup alignment if I had to.

3.3.18 SPS Burns 6 and 7

EISELE — I can cover burn 6 because that's one I did in the left seat. That was another SCS control burn with the G&N monitor, and again we found that the SCS results were quite comparable to the G&N burns. Everything went nominal, and we cut off on the DELTA-V counter with very good results. I'm sorry, burn number 6 was a G&N minimum impulse burn, which was just like burn 4, also very nominal. Burn 7 was the SCS burn. Both of them went as planned and were quite nominal in all respects. No problems.

3.3.20 SXT Calibration

EISELE — The sextant calibration, I think we already discussed this earlier. We only did one sextant calibration test. It was called for a second time in the flight plan, but we were advised to delete it from the flight plan. Apparently they felt the first one was good enough, or else they weren't getting anything out of it. I don't know which, but we did not do the second one.

3.3.21 PIPA Bias and EMS Bias Test

EISELE I did it twice during the flight, once very early in the mission, and once later on but I don't remember when during the latter days of the flight. The PIPA bias hardly shifted at all during the entire mission. The PIPA bias compensation values that were loaded in prior to launch were quite adequate for the whole flight. The difference between what I measured with the test and what was loaded in was on the order of .01, whatever the units are. (I don't know what they are.) But it was a very small difference, and it was quite stable.

It was interesting to note that the Y PIPA had absolutely zero bias in it. The thing was perfect, as near as we were able to measure. The first time I did it, I was quite concerned. I thought perhaps the Y PIPA wasn't working at all because it got no bias whatsoever for 4 minutes. The ground had the same reservation, and we actually went as far as doing a small thrusting maneuver with the RCS sideways and then back to

see if the PIPA's really worked, and it turned out that it did. It measured the velocity very nicely.

The EMS Bias Test. Wally performed the EMS bias test at various times in the flight, usually before a burn. We'd check it out, and we would simply go to DELTA-V in AUTO and watch the DELTA-V counter count. Usually, we got one tenth or two tenths of a foot per second over a minute or two. Very small bias.

3.3.21 PIPA Bias and EMS Bias Test

SCHIRRA On the EMS bias test, I tested the EMS as it would be used. I didn't feel that there was any reason to test it any other way. We did run it for one long period of time about 5 minutes, I guess, but the real valid test of that is the 30 seconds that it is ON prior to the burn plus the burn time. This should be done prior to the burn, so you will know what the residuals are from it. As an example, we had a 36-second one; it was a 6 second burn. The bias was one tenth of a foot per second. I think that is all that needs to be said on that EMS bias test. The other interesting thing I might make note of is that there was nothing on the EMS, nothing on it.

SCHIRRA I'd like to make this statement because I've spoken about it during the flight readiness review about having a hardline go across the LEB, so you won't have to make and break. I still think it would be the way to do it. You have got to have that hose in there anyway for urine-management when you're in the suits to dump from the couch. You do that; we did when we first

started out because there is no way to get all three guys down as you get ready to unsuit. So you do have to bring that hose up from the urine nozzle to a man in the suit.

EISELE — I guess on water management, the only management we did was to dump the waste water periodically. When it got up to 95 percent, we dumped it down to about 20 percent.

SCHIRRA — We did it one time voluntarily and they never called us on it.

CUNNINGHAM — There are two points I think ought to be clarified. One is the fact that you can't open B8 which has got about eight or ten cans of 16mm film in it, in our case. You can't open B8 with that little valve hooked on there. You should have a shorter valve or one coming out at an angle if you are going to have something protrude at all.

3.4.17 SPS Propellant Thermal Control

CUNNINGHAM — I would like to make sure that it is well understood that apparently no thermal control was required for the SPS propellant tanks temperature. The only time that any work was done with it was for ground request and to verify heater operation.

3.4.18 Auxiliary Propellant Gaging System

CUNNINGHAM — We used the auxiliary gaging system for the long burn, 66 seconds, and that was in order for the ground to be able to collect comparative data. The primary system worked as advertised. It was interesting to me that after the first two burns we showed more oxidizer than propellant left; but by the time we finished up, we were showing more in the other ratio. I would assume this was down within the accuracy of the meter. My personal feeling was that I had that meter quantity reading to probably about plus or minus .5 percent at best.

SCHIRRA — There's the answer. Reduce ...O_2 tank fan cycles, and that is it.

CUNNINGHAM — Yes.

3.4.26 SCS Backup Alignment Procedure

CUNNINGHAM — Have you already discussed SCS backup alignment procedures, Donn?

EISELE — Yes.

3.4.29 Launch Vehicle Propellant Pressure Displays

CUNNINGHAM — Did you want to say anything about those?

SCHIRRA — I called all those numbers down.

CUNNINGHAM — Yes. Easy to read, no vibration during boost, etc.

SCHIRRA — Let's compare my numbers that I called down with the ground readout, and if they're good, let's get those back to prime. They weren't evaluated prior to that. That's why I didn't want them to be prime. Do you get my argument on that? Remember, we called down when we were venting? I wrote them in the log. Let's correlate those with time, and if the instruments are good, let's bring it back to prime. When it's onboard.

SLAYTON — But it was neither prime onboard nor prime on the ground by the time you flew. It was no longer a consideration.

SCHIRRA — Agreed. But there's an MTS case, and there is also a leak case.

SLAYTON Okay. The MTS case we threw out.

SCHIRRA I would like to get the instruments back to prime if they checked out. If they just read the same thing I did, then I would go by the instruments. We've had a flight test on it.

3.4.30 Window Deposits

CUNNINGHAM I believe we described this in real time very adequately.

SCHIRRA We have that on tape.

EISELE We have that on tape, too.

3.4.31 Manual Retro Attitude Orientation

CUNNINGHAM Did you hit that or not, Wally?

SLAYTON You commented on all of them. I think we have all of them.

SCHIRRA We got that in real time; I didn't have any problem with that. The ground goofed on that first one. They gave me the wrong angles, and we got that straightened out in real time.

3.4.33 CSM ARIA Communications

CUNNINGHAM I would like to add a comment under Item 33. CSM ARIA communications were not really all that great. It turned out that S-band through ARIA was definitely clearer on board the spacecraft than the VHF was. To my knowledge, that

was about the only time I noticed a significant difference between VHF and S-band. For the non-ARIA contacts, the difference was negligible as far as I was concerned. It was nice to have ARIA communications, but I don't know that we ever utilized them for anything other than standing by. On the communications, it was nice to know that you had the contact. We did not have these in the flight plan. It was always passed up real time from the CAP COMM so we would have it.

3.4.34 CSM Structural Performance

CUNNINGHAM — I can't think of any comments we might make on CSM structural performance.

EISELE — Yes, I do have one. I looked at the MET after landing, and that can still be looked at, the MET glass. The failures we were seeing in that and the cracks didn't change before I exited the spacecraft. Remember, we had the little crack on one side that has been described pretty carefully? We didn't remember to tape it there.

CUNNINGHAM — No we didn't.

EISELE — But it did not change as result of landing.

SCHIRRA What you mean is that the crack we got from the burn is worse than the landing.

EISELE That is the way I would academically put it. That should be looked at and documented.

SCHIRRA A hole was put in the spacecraft after landing by someone inside, on board the ship. A Hasselblad camera lens (not ours) was dropped right where my feet were in the aft bulkhead. I am not sure whether that data has been recorded back here, but I'm sure that was taken up . . . The only other thing that we had as a surprise structurally was this loud, loud noise during entry that caused me to switch rings. That's a big opening in my mind. I don't know whether it was structural or thruster or what, but it was a very loud audible noise on my side of the spacecraft. We all went into some degree of shock at that point; whatever that was, I don't think it could have been transitionary, much too high for supersonic or hypersonic effects. This was way up there. The time that best documents this event - I would say the event occurred probably 4 or

5 seconds before I started pushing circuit breakers in. Not much more. It was an awfully fast response. Reaction time was almost instantaneous because we were hair-triggered anyway. Those circuit breakers were going in awful fast. As soon as Donn said something about pitch, of sixteen circuit breakers (only three of which were in originally), all were in.

CUNNINGHAM — Another item that comes under structural performance is that of vibration and resonances, and I didn't notice any resonances in the spacecraft in orbit.

3.4.35 Crew Activities

EISELE — I think I've evaluated and discussed practically every activity.

5.0 LANDING AND RECOVERY

SCHIRRA — We took our time aboard ship. Knowing we were going to stay overnight, we didn't rush through the medical area. I think the doctors were very cooperative on our request, giving us a little quite time. One of the errors made was about the three pair of sneakers; two were size 9, and the other was size 11. I assumed that they would know our sizes. We did have our own blue coveralls here; that's what we came home in; and they had flight suits available for us, so that was covered very well. However, they didn't have the right size skivies.

EISELE — I thought the operation after we got aboard the carrier ran about as smooth as could be expected.

SCHIRRA — I think you ought to let the crew have one good night off the ship, at least. We felt so good the next day that I just couldn't believe it.

CUNNINGHAM — I don't think that either Donn or I really realized until after it was over just how much benefit it was.

5.0 LANDING RECOVERY

5.1 Impact on Touchdown

SCHIRRA — In the flight plan, I wrote down, "Apollo landing is a crash," and by no means is it; it was the softest landing I've had in the history of this business. Not to make a Monday morning quarterback, it really was. I'm not trying to sell anything to anybody or justify my decision by what resulted in the landing; it was a very soft landing. I've had harder landings on a runway in an airplane. To add to that, it was - I'd say, the waves were at least 4 to 5 feet high.

CUNNINGHAM — It looked like about 4 foot waves on top of some pretty healthy swells -

SCHIRRA — We had winds up in the area of over 18, maybe 20, 21 knots. I know those numbers because when I sail, I know when I have 18 knots.

CUNNINGHAM — Yes, there was a squall there.

SCHIRRA — I would have taken my main down and run on the jib, which means it is over 20. I've been in the same kind of water on a real rough day off Galveston, so go get your things and get that

kind of water for egress training. It wasn't a wild sea; it wasn't a wild sea.

CUNNINGHAM No, but I'll tell you, I think it was similar to the sea we had for our egress training on 101 in the Gulf.

SCHIRRA Except for the froth on the top of the waves, the white caps, you know.

CUNNINGHAM You're right, it was.

SCHIRRA The sensation I had - we were really braced in that thing - gosh, you just can't imagine how tight we were in there. Such a surprise, it just plopped. Plopped, not a pow. Much less of a surprise, for example, than the SPS burn. How does that grab you for surprises?

SCHIRRA We didn't expect the SPS to do that, that's one. We expected horrors on landing; that's probably why I can say that very safely. The spacecraft did not tumble. That is very important to make that point clear, and we said it on the tape on the ship, I know. It rested, and we looked at each other and said, "My gosh," and I looked out the window and saw we were going over because the chutes were falling down as you would expect. It torqued us over, and we were just about X-axis

horizontal. We got the chutes off, and then I could see them going down in the water as we moved along overtaking them because they stopped once they were released, went over and beyond them; even in stable II, we were moving.

CUNNINGHAM The thing that impressed me about the thing right there, Wally, is how very quickly we were upside-down. We started covering the postlanding checklist in orbit; Wally had looked at it the night before; I reviewed it again before entry. All I had to do was put two circuit breakers in; and Wally had to turn two switches off. I was pleased that we hit the water; we looked, hit the vent, and the chute was off in a couple of seconds.

SCHIRRA I don't know how we got off....it took me 14 seconds.

CUNNINGHAM You did turn the ELS AUTO off?

SCHIRRA Yes. The coverguard on the ELS logic switch has points on it; I didn't want that out for landing. I've been trained long ago; I wanted that off again for landing so I didn't get my knee in it in case I did come up. So that was down. You know what the other possibility is? It is that

maybe it didn't come disconnected; it just collapsed. It didn't come disconnected in 14 seconds, and that is part of the reason we ended up over.

SCHIRRA We were being blown over, I knew that. We could see the chutes up.

CUNNINGHAM We were kind of going, yes, but you know the chutes were still there sometime later because I didn't see them for a long time.

EISELE I had the feeling it took several seconds before we actually got over in stable II.

SCHIRRA I disagree with you on our very hurriedly getting in II. You guys hit the switches very quickly, but you are right, the chutes may not have come off at that particular time.

CUNNINGHAM What I am getting at is that I was surprised. We hadn't really gone through this part of our checklist in training very often—you know, the postlanding part, but it went click, click, click, and they were off. It was faster than I expected, and the 14 seconds -

SCHIRRA I don't think they were off; that's the point.

CUNNINGHAM That's right.

SCHIRRA They collapsed, and we cruised along with the wind over the chutes which were in the water. We had relative motion. I remember looking at the chutes out of the left window and seeing the lines and this big squid down there. I was reminded of that poor scuba diver in Mercury days who leaped back up on the life raft when he saw that monster down there.

EISELE What was it, the chutes?

SCHIRRA Yes. Poor guy was white all the next day.

5.2 Postlanding Checklist

CUNNINGHAM There are some differences here on the postlanding checklist, incidentally.

SCHIRRA Somebody on Recovery 1 called for the beacon lights on, and I had no reason to turn them on in daylight. So I turned them on and verified that they worked.

CUNNINGHAM I think - I am not sure if they - yes, they were calling for the beacon lights. When they kept calling, I first thought they were calling for the beacon radar.

SCHIRRA Air Boss said, "No, beacon lights." I went "click," and I said, "Are there beacon lights now?" And they said, "Wait a minute and we'll

see. Roger. You have beacon lights," and I turned them back off again.

CUNNINGHAM Maybe it was because it was such poor weather.

SCHIRRA You shouldn't have to use them in daylight is my point.

CUNNINGHAM On the checklist itself, we ran through the test down stabilization portion. We got down to the part about cooling for 10 minutes and then filling float bags for 7 minutes. We cooled for about 8 minutes and turned them on. It took about four and a half minutes to upright, and we ran it for 2 minutes after upright. Thinking back on it, remember they weren't all really full up, Wally, when we shut down. Actually, we let them run on for awhile. I suspect we probably should have filled it for 7 minutes plus 2 minutes.

SCHIRRA Let me ask you this, because I came out slow. I was trying to find some gear; I couldn't find my sunglasses. I went over on your side, and then you were hurrying me up, and the choppers were coming. But I couldn't determine whether you had powered it down. Had you?

CUNNINGHAM Oh, yes. We went B buses off. It wasn't like the simulator because there was a lot of light coming in.

SCHIRRA Oh, that's right. It's the sunlight that gets bright. And the hatch was open. You're so used to getting light; in the simulator, it goes dark when -

CUNNINGHAM That's right. When you turn the main buses off, it goes dark.

SCHIRRA That's the question I had.

CUNNINGHAM Then we did go to the stable II position, stable II checklist, and the surprise I had. Remember at first it says if the battery bus is less than - I didn't really read this - but if the voltage is less than twenty-seven and one half volts, you're supposed to pull one of the batteries off the line. And I said, "Well, hell, the meter's reading zero," and then a couple of seconds later, I realized that I was reading main bus voltages instead of battery bus voltages.

SCHIRRA By the way, let's say something at that point. That was the eeriest feeling I had. I didn't know where in the hell we were. I knew we were supposed to be with the computer 1, and when that stabled II,

I was very much alone. I wasn't alone in Gemini and Mercury. Thoughts like Scott Carpenter's incident went through my mind, and all of a sudden I didn't know what to do. I said, "Here we are stable II. We may be stuck there."

CUNNINGHAM You know what added to it? You know, what added to it was the fact that the weather was so much worse, and we figured if we blew it, we must have blown it many, many miles. Because here we were sitting with weather that was not anywhere close to what we were expecting.

EISELE Yes. I figured the computer had really bombed us into some place hundreds of miles away from where we should be.

SCHIRRA We were sitting there, and Donn at this time said, "Does anybody feel sick?" And Walt and I wouldn't help him because he just went white and grabbed his barf bag, which was, by the way, a good technique, I wasn't as well prepared as Donn was for this, in this sense. Before we started down, we'd gone all over the things we were going to have in our suit pockets, (just so we wouldn't have any PTK's in our suit pockets), all the stuff we wanted to take off the spacecraft on us, and we also had

a fecal bag. Donn was smart enough to break his bag down at the bag. I just had a package, and that's wrong. We should have had our bags out. I was just hurting myself, in that I was in a hurry, and I said, "Oh, I won't get seasick." Well, I lucked out, and I didn't.

EISELE Well, he didn't take a pill. His confidence kind of bothered me.

CUNNINGHAM I've never been seasick in my life, but after being out in the Gulf, I was all in favor of taking a pill up there.

SCHIRRA I don't think the other guys did this, not get seasick, unless they got sick and just got over it.

EISELE That was my trouble. I had dry heaves; there was nothing in my stomach.

SCHIRRA There was a lot of water on your stomach; you were pulling on that water gun the last 2 days. You were drinking water all the time.

EISELE Yes, but water doesn't stay in your stomach very long. All I got up was some gastric juices and that damn Marezine pill that I had swallowed about an hour earlier.

CUNNINGHAM — We didn't do any of the next damn business because we had already planned on getting out of our suits. We didn't want to lug an extra 55 pounds around after landing.

SCHIRRA — I didn't manage to get all the way out of my suit by the time that the hatch was opened. I was down in the LEB wrestling with it, and it's awfully hard to get out of those suits. I can only say that the liner must be attached to the suit in order to get out of it easily. The neck ring and my arms both came out when I got the suit off. Everything else just peeled apart.

5.3 Communications

SCHIRRA — COMM was a problem; they just barely got us before touchdown. And then, they snapped out as we went under the water, and so did the VHF.

CUNNINGHAM — Then we got to the stable II checklist; we turned off the radio, and after uprighting again, we turned it back on, and it worked fine. Incidentally, we had VHF COMM on the way down.

SCHIRRA — They heard us, and they heard me say "IFR clearance stright in, no delay expected." They got a big kick out of that one. They also got three-way cuts on us on their electronic homing gear. They had lots of electronic gear. That's another one I want to bring in while I'm talking about COMM. This particular ship as an anti-submarine warfare ship has an airplane they call the E-1 electronics airborne CIC. They really had us cold. They picked the spacecraft up in the water on their radar. It has a 17-foot radar antenna. They picked us up, no strain. It's a damn good device to have out there on the recovery force. That backed up the cut we had; we had a three-position cut. For some reason or other that beacon didn't work on descent.

CUNNINGHAM — I'm suspicious about the fact that we've got two separate antennas that come out, and I know that it's kind of a tricky antenna to stow before launch and to come out. I almost have the impression that it hung up, that the one that the beacons are on hung up and eventually broke loose.

SCHIRRA — Voice COMM was very good, I think. It might be worthwhile to bring this up. You keep forgetting that you don't have the big heavy transmitter that everybody else has, and you can't understand why you can't talk back when you hear everybody. That's just the problem; it never will be changed.

5.4 Spacecraft Status — Spacecraft's status are all GO, other than the batteries are probably low, and we all knew that.

5.5 Battery Power

CUNNINGHAM — By this time, after we'd cut the loads off - any of the main bus loads - we were sitting at about twenty-eight and a half volts on each battery bus, and it had been working its way up from the 25.2 we had on SEP, until we were actually up to about twenty-six during re-entry. We had been creeping back up, but for postlanding, we had about twenty-eight to twenty-eight and a half, something like that.

5.6 Postlanding ECS System

5.7 Ventilation

I goofed on the ventilation and internal temperatures; it all comes together as one thing. In the stable II position, you cannot get any ventilation. There's no suit band; you're just living on an open suit. There's another reason for not having the helmet on, not that I even thought of that beforehand. We would have had to have our helmets off -

CUNNINGHAM We would have had to take them off right away in any event.

SCHIRRA Right after landing, as soon as everything settles down. We did know that we had to get the helmet off, but that was not one of my considerations prior to re-entry.

5.8 Internal Temperatures

SCHIRRA — We were really dying in there of the heat, I hit this thing and said, "Well, that must do something." Walt's got this sock hanging from face, and whoosh, it's gone, and the whole cockpit occludes. It just fogged up -

CUNNINGHAM — I didn't even have a duct on the thing, and it was blowing down nicely on me. I think there is a point to make here, Wally, and that is that subsequent crews really - that little phase, when you run through the simulator on re-entries, you generally don't really run through this stuff -

SCHIRRA — Well, what we didn't do, Walt, was play it all the way on water egress in the Gulf.

CUNNINGHAM — Yes, that's right, because we were so anxious to not -

SCHIRRA — We had one part we were trying to get done, which was to get that survival beacon radiating to the spacecraft. By the time we got into the Gulf (this version for egress), Walt went down into the LEB and we had the hatch open by that time. Walt came crawling out of there; he was getting sick; and from then on, it was all get

out. I guess that's why we blew that particular phase of that training, or I would have played the switch, and we would have had the ducts out. We were in a hurry to get out of there. I guess that was our mistake; we shouldn't have done that. It wasn't fatal, but it's something the other crews can take advantage of. Oddly enough, in my estimation, the spacecraft was more confortable to ride in as a boat in stable II. It's a lousy position to be in -

CUNNINGHAM I agree with you.

SCHIRRA - but it damped better in the swells and waves -

CUNNINGHAM Actually, there was far less motion -

SCHIRRA I think we'll go ahead and make that a recommendation. You can't get fresh air, so that's a problem. There is no way to use that as a technique. There in stable II is where we saw - I think my description of the windows will hold now - 1, 3, and 5 getting water inside up to two panes away from us. It means they're vented, and that's why they got this condensation on them. There's no sense running detailed studies on the damn things; they've been washed off with salt water. They whirled up and down

inside them just like you're trying to wash them. They're all scrubbed off very nicely. Now you can see water crystals in there. Numbers 2 and 4 were not vented, and it's quite obvious that water didn't come in. Another thing we noticed in stable II was a little bit of water down in the tunnel hatch area, which is our own water.

EISELE We....off those glycol pipes for several hours before deorbit, so I'm sure that a good bit of water collected in there. It just ran the lowest point, which happened to be the tunnel hatch when we were upside down.

5.9 Spacecraft Attitude

EISELE The spacecraft attitude was very poor. Donn's whole world came to an end. That's about it.

SCHIRRA But when we got back to stable I, we were trying to get the postlanding ducts from Donn. He had them in his pocket, and he was down in the LEB bemoaning his fate, loudly bemoaning. We finally got all up, and Walt gave me one shorty. We couldn't feel any flow at all, and I went down below my girth ring. There's a postlanding vent valve control, and I said, "It's on NORMAL. Okay, Walt, pull the lever." And Walt dutifully pulled the lever up there which is the overlock. For some reason or other, I didn't turn the damn switch on.

CUNNINGHAM It's supposed to go to HIGH.

SCHIRRA It has a vent switch; I've looked at it for all these years and never used it.

CUNNINGHAM We let it sit there for quite awhile, because I remember saying, "They're hanging there."

SCHIRRA The real fun of this is I finally - sometime after -

5.10 Couch Position

SCHIRRA — On the couch position, as far as I could tell, I looked at the struts, and I'm sure that the people have done that since those couches didn't stroke from 1 mm.

CUNNINGHAM — It would take 22 g's to break it out, wouldn't it?

5.11 Internal Pressure

SCHIRRA — Internal ... There was no problem with that. We did use the dump technique and locked up at the - what was it, 1 000 or whatever you -

CUNNINGHAM — We were locked up before the mains. Oh, no, between drogues and mains, we went to dump instead of just to boost on re-entry. We had time to do it, and this was just -

SCHIRRA — We were not rushed on the way down. We really weren't. In fact, I didn't make that point way back, but at .05 g in re-entry, I said, "Okay, tighten up, gang," so we tightened up on our straps. We tightened up again after drogues, tightened up again after mains. You're squeezing the couch to 1 g. That was my point. We really had ourselves tighten up. At zero g,

you can't get your butt forward on the suit or the seat pan, and when you get the 1 g weight on there, you just really went in. The harness did move.

SCHIRRA We used the locks on the harness positions in zero g for retention. I was worried about the straps; they became a little more supple, (if I could call it that) than they were originally.

EISELE You did mention it was very hot in there.

SCHIRRA Yes, indeed.

5.11 Internal Pressure - cont'd

CUNNINGHAM Just to make the point real clear on internal pressure, we did go to the dump position on the one cabin pressure relief valve, which allowed us to get rid of about one psi differential. And we did close both the cabin pressure relief valves at, I would estimate, 800 feet, something like that. Right, Wally? I didn't start reading to you until you called a thousand. Well, at someplace less than a thousand feet, we locked them up so that the pressure differential was not very much.

5.12 Recovery Operations

SCHIRRA On recovery operations, we mentioned the fact that we didn't hit the SARAH. One of my biggest surprises was that I felt - I read the recovery stuff before we left.

5.13 Grappling Hook Deployment

SCHIRRA I thought it was going to be a call from them to throw out the grappling hook if they wanted. It turns out that the only time they use a grappling hook is for the pyro medic type deployment. When you use choppers, you don't need the grappling hook. So that's the tip on that.

SCHIRRA The ship wasn't even trained for it because they didn't have that requirement.

CUNNINGHAM They hadn't even heard about it.

SCHIRRA They were all surprised. The Air Boss, the carrier, and the skipper -

CUNNINGHAM Where it did affectus though was when Wally said, "Do you want us to deploy the grappling hook?" because it requires a little lead time.

SCHIRRA They couldn't understand me, said I was garbled

CUNNINGHAM We were talking to the copper pilot, and he said he didn't hear it. He said if he'd heard it at all he probably would have said "Roger," meaning we would have been busy. Instead of getting out of the suits, we would have been busy going under the couches and trying to take the screws out and throw that silly thing out -

SCHIRRA - when he didn't really want it. At dinner that night, he said, "If I had said, 'Roger', he wouldn't have understood." That meant we would have gone all the way underneath the LEB under the couches to get that thing out. So that was kind of a bad one. On the other item, I found out why they didn't want me to hoist aboard, which I might have considered; as it was, they were so far away from us. The reason they were not right there was because the skipper took the ship and moved it out of there. He wanted to get out from underneath us, and he took the choppers out from underneath us, too. That's the only risk, I think, in coming in in low ceiling areas. They don't have time to dodge you if you really are in the predicted landing place. So that was a pretty good hit, I'd say. At any rate, that was one of the reasons why it took a little longer for recovery than it normally would have. We were about 4 or 5 miles from the carrier, away from the spot. If it had been the blue-bird day they had the day before, they would have been prepared and suspected that I would be hoisted aboard, but

I agreed that I wasn't going to be. But it would have been perfectly alright to have been hoisted aboard on a clear, calm blue-bird day. Doc said the ship was an old ship built in '43 and he was a little worried about stressing the gear. This was just a feeling, not an engineer-

5.14 Egress

ing job. The egress out of there was no strain. They had two life rafts outside, had a JG scuba diver type and two other men there. They handled themselves very well; so there was no problem. We just got out one at a time, and then they picked up all three of us. There was drizzling rain when we were getting out. We just flat-out got good and wet anyway. That's one reason I don't like to get out. You just get sopping wet.

REP Did they have COMM with you before you got out?

SCHIRRA No, and this is interesting. In stable II the sea dye marker was leaking out. We could see it. So I said, "Oh, it must be in automatic deployment; I didn't know that." But it wasn't and it turns out that you have to deploy the sea dye marker to expose the phone jack. They couldn't find the phone jack. That's the

reason they didn't get to that. But that's the key to it. They can't get to the phone jack unless you deploy the sea dye marker. So it looks like SOP is - that you've got to deploy the sea dye marker no matter what. That was something we never even knew.

5.14 Egress

SCHIRRA — When we got the hatch open, as every time in the past, in the block I training, either in the tank or out in the Gulf, it was always the same: we wanted out fast. The other thing we wanted was to get the suits off. They are hot and terribly uncomfortable. We had to help each other get the zippers undone. I got out of the suit and into the raft. There was a scuba tank in the raft.

EISELE — We got sopping wet just from getting out of the spacecraft and getting in the raft. I was just about shot. If I had had to put on one of those air-tight suits that they're talking about for the lunar returns, I would probably have passed out. You could run a good risk of that happening to somebody, maybe losing a crew member because of that.

SCHIRRA — I recommend a little cargo net around the raft that they can go in and not drown so that they would be able to cool off. The internal medicine is something else you are going to have to work on, but externally, there is no reason to isolate it.

CUNNINGHAM Stay away from any other suited operations. We definitely wanted to be out of the suit because of the load that it would put on us. Getting back into our inflight coveralls was difficult. We were all sticky and wet, but we insisted.

SCHIRRA They did have clothes in the chopper for us to wear.

5.14 Egress

SCHIRRA This comment should be logged under area 5.0 and had to do with postland hatch operation. All during the early part of the flight, we noted the pressure on the hatch decreasing, and there was no callout for it. I elected to put the lever that was in the PRESS position to the NEUTRAL position to isolate the bottle from the hatch cylinder in case the cylinder was leaking, and over a number of days, it's not unreasonable that it would leak out. This way, we could save what was left in the upper bottle, the initial bottle, for the hatch operation. In postlanding, when we got back to stable position I, Donn Eisele, who is normally our center couch hatch man, wasn't available. This is part of my point.

Fortunately, I did work with it enough when I was involved with the design of the system and I knew how to work it, but I had never actually done it. In this case, I had to do it. Walt was busy helping Donn, and I was the only one available to work on the hatch at the time. I ran the press lever outboard, and nothing came up. That bottle was green, so I had to bring the second bottle on the line to get the hatch to open.

REP How hard was it to operate?

SCHIRRA No problem at all. I had never operated it before with gloves off.

REP Barehanded?

SCHIRRA I think that's the first thing we might as well face up to. If you were doing it, you are going to be barehanded. You don't need the counter-balance in orbit; you better not in fact. There are two things from that: one is that all crewmen should be trained to run that hatch in that phase of flight, the end of the flight, not early in the flight because then you are in orderly progression of events like countdown.

Because I was so involved in the design of the thing, I knew exactly how to do it. I've never trained for it, just fortunate in my case. We were in a hurry to get it open because Donn was in bad shape and needed some fresh air.

CUNNINGHAM I didn't realize that fact. You went at it even though you hadn't worked it before; you didn't seem to have any problems.

SCHIRRA No, I didn't because I was on the drawing board the day they designed that thing; that's the reason I knew about it. We were just talking about the fact that I had to use number 2 bottle to open that hatch.

CUNNINGHAM Incidentally, it didn't really drive that hatch off with great dispatch. No great exuberance, no.

SCHIRRA It was surprising though to open up and get rain in my face.

EISELE Boy, did that feel good!

SCHIRRA What a transition though from this great sound little vessel with after-odors to the outside world. That's a point I'm glad I thought of; it just crossed my mind. It had to do with valving; that's as far as I'm concerned.

5.16 Crew Pickup

SCHIRRA I thought the pickup went off very well. It was lousy weather, and that chopper pilot really worked like a dog to get in there. He had a lot of wind, and the spacecraft was blowing along, and this was a real hard job.

SCHIRRA He did great; he did very well. We got into the chopper, ... was in there with some drinking water for us. Right away Donn recovered; almost immediately, and I think he said, "I'm now back in my element."

REP In chopper flying?

EISELE I was airborne, anyway. Back in my natural element.

SCHIRRA It was kind of nice to see the doctor we had worked with there, and he was prepared to go over the side ...

EISELE Yes, he had a -

SCHIRRA We took our trusty little combs and combed our hair and sat back and relaxed.

6.0 SYSTEMS OPERATION

6.1 Guidance and Navigation

6.1.1 ISS Modes

EISELE

Item 1. ISS modes. ISS CDU's appeared to work perfectly throughout the flight as far as we could tell. We always got sensible numbers on the DSKY, for instance, if we wanted to look at gimbal angles, and the coarse and fine alignment of the IMU and so forth. The interface between the computer and the IMU appeared to work nominally; in fact, it worked almost perfectly. We were really astounded with the performance of the whole system. IMU turnon and turnoff was a very simple thing to do. It operated just as advertised. The caging (which we could do by manually calling the coarse align routine or in some of the normal alignments, cage the IMU or drive it to a certain attitude) seemed to work just fine; we had no trouble. Actually, we never did use the cage switch. If we ever had occasion to cage the IMU - that is, put it to NULL, we did it by means of the computer with the VERB 41, coarse and fine aligning. The coarse alignments that

took place in the alignment programs varied quite a bit in terms of the gyro torquing angle errors that we got in the subsequent fine alignments. I think the reason that we sometimes got rather large coarse align errors was because often the spacecraft was moving when the coarse aligning was going on, and rather than waste or use up TCS fuel to stop these rates, we simply let it drift on, and this generated considerable error, sometimes on the order of 5 degrees coarse align. This wasn't the problem either. It was surprising the first time it happened, and I got to thinking about why it did happen, and it was obviously the spacecraft motion. Normally, a coarse align error, with the spacecraft reasonably stable, is on the order of a couple of degrees if you are going from one attitude on the ball to the other. Fine align routines worked beautifully. I was very pleased with the results of that. Usually, if you were doing a P51 followed by a P52, when you do the fine alignment the first time through, you would take out the coarse align error with

the gyro torquing numbers; and the second time through when you do the fine align, these numbers would be down in the thousandths of degrees, typically, or hundredths of degrees at worst. I found that IMU drift over a period of several hours was very small. You do a P52 fine align, and you would find again that the gyro torquing errors were quite small. I am sure the quantitative data is available on the tapes and so on. Display of attitude errors. Really we didn't make much use of attitude error displays that I can recall, just never found it necessary. The feature that we did use was the attitude set feature, where you use the attitude error needles to indicate a difference between what you have set on the attitude set knobs and what your actual attitude is, either in reference to the IMU or the GDC.

CUNNINGHAM Did you mention under one of these categories on the alignments, that in all fairness in all alignments we did - and I don't have any idea how many, I must have made a dozen myself and you made a lot more than that - we never had a final difference greater than four balls 1.

EISELE Four balls 1 was the biggest we got; in fact, I'd say two thirds of them were zeros.

6.1.2 Optical Subsystems

CUNNINGHAM Very good optics performance, which is the next item here. Power, that must mean one power telescope which they are talking about. I have already discussed the optical qualities. Basically, optical qualities of that telescope were identical to what we see in the simulator. There is a great deal of light loss in going through the instrument, and there is some distortion and blurring at the outer edges. I guess that also covers the light transmittance. It's not too good; you have to get dark adapted before you can see stars very well. Mechanical drive is excellent in both RESOLVE and DIRECT modes and at any of the three speed selections. The drives for the sextant telescope are just very smooth; and tracking anything, be it landmarks or horizon, or stars, whatever, is very easy to do. Even with the spacecraft rotating up to half a degree a second, you can track stars very easily in the sextant. And I guess the mechanical drive for both of them are comparable.

EISELE This has to do with the dumping. I think I've covered that before, but we will mention it here. At certain times, notably near sunset and sunrise, if you happened to be dumping fluids through the overboard dump at the time you are looking through the optics, you will see snowflakes out there which look very much like stars. You see a whole field of them, and it just obscures the entire star field. You can't tell the stars from the flakes of frozen particles.

REP Does that occur during dumping?

EISELE Yes, it occurs during dumping, mainly just before sunset and just after sunrise, if it's broad daylight. Usually if you are looking at the earth or some bright view there, they don't show up; and in the darkness, there is no light from the sun to reflect on them. This will be a problem on lunar missions; and I guess on a lunar flight, you will have to plan ahead to do your alignments. You will have to plan your ventings and dumps so that they occur at some time other than when you plan to do IMU alignments. OSS moding, zero optics mode worked

pretty much as advertised. There is a good deal of overshoot when you go to zero optics. We did not bother with the ground technique of driving the trunnion angle to near zero. We simply threw the switch -

6.1.3 Computer Subsystem

EISELE Computer subsystems: I don't really have much to say regarding instructions of programs other than that they seemed to work substantially as advertised. The one anomaly which I have not yet gotten the full word on is the business of the improper exit from program 20 which apparently set or reset a mark flag such that the next time I attempted to do marks with it, it would not take the marks. I think this is an anomaly that should have been uncovered and put in the so-called program notes. It was apparently a constraint on using the computer that we did not know about before flight. In general, I think that the programs in SUNDISK have been critiqued and criticized long before flight, and they are time-consuming and tedious to the extent of extra button pushings over what would really be required. I'm sure that

the Colossus program will rectify most of those shortcomings.

EISELE The CSS timer: the only timer function that we were aware of on board was the occasions when we called up the CMC clock time. It was always right on the money with the CTE; we never had a problem with that. In order to keep that clock from running out of time - running out of bits in the section of the computer - you have to power up the computer at least once every 24 hours. That was not a problem because we powered it up every 8 hours or so anyway just to keep the state vector integrated forward so that when you did need the computer, you wouldn't have to wait maybe 20 minutes for it to catch up to present time. The display and keyboard - I'll skip these other items because I don't know anything about that; those would have to do mostly with the internal workings of it and that would be derived from ground data. The DSKY and keyboard worked quite well as far as I could tell. All the buttons worked; we didn't have a single failure of any little element in the registers; we had no failures or problems with any of the buttons. The status lights and warning lights

worked just as they should. We did have a few restarts during the mission. The only one that was of any concern was the one that took place when we were trying to do program 22 and mark on the horizon. This was a rather hastily conceived test, I think, and was not properly checked out on the ground before it was read up to us. When I performed this exercise, we got a program alarm, a restart light, a CMC light, and the computer hung up, froze such that we could not make any entries into it with the keyboard. We deliberated several minutes before taking any action, and I finally decided to try the so-called GO JAM technique which is to simultaneously punch the MARK REJECT and the RESET buttons. I did that, and it freed the computer, took away the restart light and the CMC light, but the program alarm stayed on. I called up VERB 5 NOUN 9, and I got some alarm code which said, effectively, that the computer was trying to deal with square roots of negative numbers. That indicated that there was something badly wrong with trying to do landmarks when they're out on the earth's

horizon. Anyway, we got out of that problem, and I wasn't sure at the time what we might have done to the erasable memory. In the ensuing passes over the ground, they were able to verify that the erasable was still in good shape and that it hadn't really hurt anything. We got out of that one pretty clean. I did a flag bit check only once that I recall, really, and it was to set the prak flag for the deorbit alignment in which the ground loaded in REFSMMAT numbers. In order to align to that, you have to manually set that flag rather than do it through program 40. We did that, and it worked fine; we just called up the appropriate address, looked at the numbers, added one to the bit 4, and loaded it in. At one time or another, I did perform the CMC monitoring and the self-check and so forth. All those little tests behaved just as they were listed in the check-list, never found any real problem with the computer in the whole flight; it always checked out clean as a whistle. I never did a manual computer restart except for the GO JAM technique which I just described.

6.1.3 Computer Subsystems

SCHIRRA This is a point of consideration if you go out 3 days, for example, and are trapped on the lunar mission. Is the computer going to be good? You can't get enough experience with it. We had a lot of SUNDISK time; a lot on the hybrid in Houston, SUNDISK, ME101, even the DCPS and the CMS here, so we had a pretty good feel for it. Right down to launch day, we were getting little sneaky, funny looking things as we called them, FLT's that came in from Houston and from Boston, little tricky ways of playing with SUNDISK. In real time, we found one where we exited program 20, a new way that we never heard of, and that was chasing the S-IVB for tracking. That was why we couldn't get it to MARK the next day. They found a way of doing it that was good. Then all of a sudden they conceived of an experiment which they did not cycle that through the computer, and that blew the computer for us.

EISELE They didn't have time to run it on their hybrid, but they should have done it on the hybrid.

SCHIRRA They had time after we bombed out. They had the data back in an hour and half. That's my point, and I would like to stress this very thoroughly. Nothing will ever be updated in that computer that hasn't been done someplace else before. That way, the reliability will stay up.

EISELE It isn't that you hurt the computer per se. All you do is run a risk of perhaps messing up the erasable memory or resetting flags. If you have good ground contact where they can read out the erasable memory, they can fix all of that for you anyway. It is primarily a procedural difficulty that you run into in flight, which can mess things up.

SCHIRRA But that is what got us out of the woods, and that was a sneaky way to restart a computer.

ALL It's standard.

EISELE We could get LOCK OUT like that.

SCHIRRA I didn't even know Colossus has it.

EISELE I imagine it does, or it may be the type that doesn't get into those locked conditions.

CUNNINGHAM While we're discussing the procedures for G&N, I think we all have to face up to the fact of

possibility of a new procedure coming up, and it ought to be checked out. The same thing holds for the other systems, too. It's like the servicing of the secondary water evaporator. We had a procedure passed up that everybody had insisted was physically impossible to accomplish for years.

SCHIRRA Someone went and psyched it out. That was the forty stroke deal?

CUNNINGHAM That was a four step procedure, but it involved turning the water on for 2 seconds and off for 3 seconds and doing this forty times.

SCHIRRA Everybody has been going over this for 2 or 3 years to find a way to service the secondary water boiler, and they said there was no way. They all said that in real time there is.

EISELE Did they check that out Walt? Or was that just somebody's good idea?

CUNNINGHAM I just want to go into it briefly here. The reason the redundancy check was made each day is that they said you couldn't go more than about 24 or 30 hours before the water boiler dried out, and there would be no way of reservicing it. I'm hoping that in doing their work with

the primary evaporator, somehow they checked that procedure out. They had passed that procedure up anyway, and it never should have been passed up if it was not done and verified several times in a vacuum chamber someplace with an evaporator.

SCHIRRA On the computer, if everything is done in an orderly fashion, there are no surprises except for new programs that haven't been exercised or new parts of the total program that haven't been exercised, like this P20 exit. That was a real surprise to us. I guess the manual computer restart is our go-jam. That's what I interpret that to be. The other thing we were very worried about was gimbal lock every time we brought the IMU up. I think if the station is vacated so that you can control the spacecraft attitude, then to go on the SCS max deadband until you get back. I think it is joing going to drift. It seems to be boresighted for the gimbal lock area. It's a shock, particularly in earth orbit, when you get an alignment at night. You think you're just going to blow it.

REP — How about the flight objectives? Are you going to feel comfortable enough to get an update on board to do those.

EISELE — I never really checked many. I think the only one that I can remember looking at specifically was that prat flag for the deorbit alignment.

SCHIRRA — I think, particularly in a lunar mission, with people who look at that all the time, you shouldn't have to do all that.

EISELE — No, I don't think it should be part of normal procedures to go in and fool around with flag words because you can really mess up the works if you get in there and set some the wrong way.

SCHIRRA — I know one thing we never brought to anybody's attention. It may be in the checklist. I think we put it in and that is to brighten up the DSKY in the lower equipment bay when you're committed to the couches.

CUNNINGHAM — That's right. We got it in the checklist. We added it in the last couple weeks. It's lower equipment bay, DSKY bright.

SCHIRRA — That's just so you can see it, in case MDC fails.

CUNNINGHAM There are certain failures where you can keep punching the numbers in from MDC on 2, but the lights don't come up so you can read it on one.

SCHIRRA I think that's a real hot tip.

6.1.4 Rendezvous Radar Modes and Programs

EISELE Man, I wish we'd had a rendezvous radar, but we didn't. We did have the rendezvous radar transponder, but we'll cover that -

SCHIRRA We didn't have them, we had the transponder. We weren't too well prepared for that transponder, I must confess. We didn't have the procedure onboard.

CUNNINGHAM That's right, we didn't have the procedure for checking it out beforehand. They passed it up.

SCHIRRA The heater had to be on. We had to call for that. This is a little embarassing from our truly professional attitude.

CUNNINGHAM Well, I suspect I dropped the ball in not having that in the DTO.

SCHIRRA That may be right.

CUNNINGHAM The people that we've had to work with on several different occasions on that particular DTO have never seemed to be very familiar with what we have in the spacecraft. After the first couple of meetings, they had switched names and things

that we didn't even have in the spacecraft. And I think there was a lot of money spent on this test, but there was not a lot of intercommunications where they understood how we had to run it and understood what was necessary to run it.

SCHIRRA Your point is valid. You've got to give the crew the option of when they learn something to vary from it, and I could not get that point across in real time. When we found that perigee torquing problem, it was brutally expensive and yet the task they were asking us to perform required minimum deadband. Donn discussed it with this guy for months about the fact that we can find an answer. You don't have to have it in minimum deadband to get to this attitude and keep it in minimum deadband for 26 minutes. Just tell us what attitude you want us to start in, and we'll do that. That was the Roll Passive Thermal and the Pitch Passive Thermal. Just fly it to that and then you let it go. Just like you let go of a stick in an airplane. You don't have to have the autopilot to put you in a perfect attitude. Although I blew it in real time by acting up, I guess. The point is still valid and I don't

want to lose that point. Accept the fact that we are going to learn something in the flight. That's why we're up there. And in all these years, I'll have to admit I was very content about IVA and as you saw enough movies you were perfectly happy with it. There is no problem in IVA. We had a lot of film on board just for that purpose. I wouldn't bother unless you just wanted some "gee whiz" picutres on IVA. We didn't carry film for that.

CUNNINGHAM As a matter of fact we discussed several things. We had a list of possible subjects for IVA. We agreed it was so easy.

SCHIRRA I said we had to have something.

CUNNINGHAM That's right, you have to go back with evidence.

SCHIRRA I do feel we can stop taking movies of IVA.

CUNNINGHAM I fell, for IVA, there's no reason at all for anybody ever to get in a water tank. Not for the command module.

6.1.5 G&N Controls and Displays

SCHIRRA We discussed EMS quite thoroughly. We talked about the fact that I could not get the GDC description on FDAI number 1. It was good thinking from the ground not to go ahead and

fool with it. I agreed immediately because I knew I could bring it back. That's enough on that subject. Gimbal position, fuel pressure indicator, no problem there. I just called down in real time that when we pulsed in yaw, or in pitch, the appropriate GPI motion is discovered. We then tweeked with it. There's nothing wrong. It's just that it's there and you've got to be surprised to see it moving. It happened on the ground, too.

EISELE The DELTA-V counter of the entry monitor system turned out to be quite accurate. We performed a bias check from time to time, and it was on the order of a tenth of a foot per second buildup in perhaps a minute or two of running. It was very small. We did have an anomaly which I think Wally's already mentioned, of the 90,000 coming up on the EMS DELTA-V counter when you were switching functions with the rotary knob. The only time that really bothered me was when it came up spontaneously when we were not switching; this just before the burn 6. We were doing an SCS burn, and we were going to let it cut off on the DELTA-V

counter. I had loaded in the appropriate number, whatever feet per second it was, and we were sitting in DELTA-V and STAND BY. A few seconds later, Wally called my attention to the fact that we were reading 90,000 and some odd feet per second. Apparently, the thing had just spontaneously put that number in there. I recycled it, reset it, and it got through the burn fine, but we were really watching that one like a hawk. If you had that large number in there, the DELTA-V counter might not turn the engine off at the right time. This was an anomaly, but it never proved to be a serious problem. The entry monitor system per se, the part that has to do with entry, failed miserably as we knew it would because our preflight test had shown that it consistently failed the little test that you do to verify it. In fact, during entry it proved to be completely useless in terms of flying a guided entry. The FDAI instruments were quite accurate; they were easy to read; and they were very useful instruments. Probably the best thing we had on there to fly by was that eight ball.

EISELE ... I think I'll ask Wally to cover that. Apparently at one point, when he switched to put the GDC reference on number 1 ball, it caused the FDAI number 1 to do a 180-degree flip. We never troubleshot it because the ground advised not to do it for fear of fouling up the works somehow. I would like to mention that the one inherent problem you have with this three-gimbal platform is the gimbal lock problem. We went into gimbal lock one time, and we nearly did it on several other occasions. The problem seems to be that the three-gimbal platform in combination with this perigee torque thing was creating a buildup of high rates up to perhaps a half a degree a second or greater in the vicinity of perigee. This would torque the spacecraft around such that it would often approach gimbal lock very closely. If you weren't watching it very closely, it would drive it in. That's what happened to me that one time when I had the rates down very low. I had observed for about an hour that as the spacecraft went through some very mild cyclical motions, it would traverse out to perhaps

30 degrees yaw angle to one side or the other and then come back; so I was satisfied it would run and that it would take care of itself over a period of several minutes. I went on about something else, and just then, apparently, we went through perigee, and the thing torqued itself right into gimbal lock. It was a little embarrassing and disconcerting, and from then on, we kept a very close watch on it. That could be a problem, incidentally, on a lunar mission. I don't know how much torquing you have to get on a translunar flight, but if you have the platform powered up and you intend to maintain some alignment continuously, you are going to have to post somebody on watch to keep an eye on the bloody thing or it's very apt to go into a gimbal lock and lock itself up.

Gimbal position meters seemed to work as they should. The scaling and resolution on them is not as fine as you might like, but they seemed to be adequate to the task of monitoring the SPS gimbal position.

The attitude set control panel also functioned properly; we had no problem with it. We - at

least I never went into an accurate check of any bias in the wheel settings themselves. If there were any biases, they were extremely small because we were able to make very close comparisons between IMU and GDC alignments through use of the attitude set wheel. All I can say is that the rotational handcontrollers worked just as advertised throughout the flight except for one time when we had an apparent sticking of a breakout switch in pitch on hand-controller number 2. It was toward the end of a very active day, and we decided rather than troubleshoot it right then that we would power down the system and check it the next time we came up. The next time we came up, it wasn't there, so we never did find out what caused it or where it went. The number 2 controller hardly got used at all. We did run through a check of it through the use of the computer by calling up the appropriate channels and looking at the input channels to the computer. We could verify that the number 1 handcontroller was putting out the right signals. I presume G&C switching interfacing refers to the manifold

switches on the left-hand console. There are a great number of them, but they are arranged more or less logically, and they're not at all a problem, I don't think, to keep track of and manipulate. You do have to keep your mind on it because it's possible to select the wrong mode or perhaps be in one mode and intend to go to the other and forget it. We found, in general, that the switching worked nominally and there weren't any problems with it. Do you recall any problems with the switches on the left-hand panel?

SCHIRRA No, not a one. I would like to know what the heck happened to that handcontroller.

REP Back up to B there, Wally, do you have a comment on the FDAI, the flip 180 degrees?

SCHIRRA Yes. We could not transfer GDC to FDAI number 1. First time I did it, it worked I'd say about 5 or 6 minutes reading GDC. Then, all of a sudden, spontaneously, it just flipped almost 180 degrees, not exactly 180 degrees but within about 10 degrees of 180 in pitch. Roll and yaw were right where they were originally. Then I tried again later, I realigned the

GDC, thought I'd lost it, then I found out that wasn't required, went back to ball number 2, looked at GDC, and it was fine. Then I tried to bring it back over to number 1 by selecting number 1. All proper switch procedures, that's my whole point because it wouldn't have gone there in the first place if it hadn't done it properly. Nothing to do with the ORDEAL box, and then it just went over and flipped right away. I could never get it to work. Then the ground said, "Don't do it anymore," and I agreed I wasn't going to, knowing I could bring that part of the spacecraft back and check it out. I'd rather not troubleshoot something like that. I didn't need it there, but that left me with no choice but to leave GDC on ball number 2 for reentry rather than put an ORDEAL display on there and subsequently stow the ORDEAL box. That's not a total failure in that sense, but it obviously shouldn't be doing that. It's a malfunction.

6.1.6 Procedural Data

EISELE Okay. I guess we've covered the switching and interfacing procedural data. DSKY operations

and VERB-NOUN formats: I think I've already mentioned previously that as far as I could tell, the DSKY operation was substantially nominal for the whole flight. The programs changed through their routines and displays as they should. All I can say is that the whole G&N system throughout the flight performed beautifully and as nearly perfect as you could ask for. If anyone has any specific question concerning program detail or procedure, I'd certainly be glad to answer them later, but I really don't have much to say other than it was a good show for the G&N system.

SCHIRRA Attitude set, that's no problem. Hand controller, no problem. G & C switching interfacing, no problem. Procedural data, no problem.

6.2 Stabilization and Control

SCHIRRA Okay, that's no problem. All attitude reference systems were great. The only thing I can stress was the surprise - and it shouldn't be - that if this feels like a big ball, just imagine how big it's going to feel when they pull off the S-IVB.

EISELE And when you got the lunar module hanging on the front end to boot.

SCHIRRA Accel command is a great mode and I like it. The only problem with accel command is that you've got a "hot stick" and if anybody bumps it, you've blown it. Where in pulse, if you're "hot stick," all you get is one pulse if the guy bumps you. We had one case where it was a combination of problems: I left pitch in accel command, and all three of us raced over to look out Walt's number 5 window to see the hurricane. Donn came up and kicked the stick, and I never before got back into my couch so fast. We had about 1 degree per second in pitch and I stopped it. That was the end of it. I goofed by leaving in accel command and Donn goofed by hitting it.

EISELE That's a good point. There's an awful lot of traffic in and out of that center couch and

both hand controllers are right there. You do have to discipline yourself to remember to keep the doggone stick locked up when you're not using it. You also have to discipline yourself when you're going through that passageway to be careful you don't bump into those things.

SCHIRRA That reminds me, on the number 1 stick, which is the one between you and Walt, you made note of the fact that there was a cut in the rubber boot.

EISELE No, I overlooked that. There was a small cut on the rubber bellows at the base of the hand controller.

SCHIRRA On Walt's side?

EISELE I think it was on Walt's side, on the inside.

SCHIRRA It must have just come from Walt's egress or whatever. I looked over number 2 stick which is the one I used for attitude control and the rubber bellows was completely intact all the time. It wasn't after landing, and we want to make note of that cut on number 1 stick prior to landing, and none on number 2.

EISELE That rubber is very delicate and it wears through quite easily. So you have to be careful.

6.2.1. Control

SCHIRRA

We ran a fairly careful calibration of how many pulses in pulse mode were required to produce a given rate in all three axes. The rate we used was .2 degrees per second. In roll, with two-quad authority rather than four, we had seven to eight pulses required for two tenths of a degree per second rate. For pitch and yaw, it was about ten to eleven pulses per two tenths of a degree per second rate, which really

6.3 Service Propulsion

6.3.1 DELTA-V Thrust Switches

SCHIRRA — DELTA-V thrust switches, no problem. I guess everything was great. I had rather not make a big disucssion on something if there is no problem.

6.3.2 Engine Thrust Vector Alignment

SCHIRRA — The ginbal movement is detectable not by a physiological motion, but I think it is detectable from looking at the rate needles. If you are in 1 degree per second you can see the spacecraft tweek a little bit, particularly on a DAP check.

EISELE — I could feel them though, when they went.

SCHIRRA — I felt them on the ground; I didn't feel them in flight. I was looking for it. Maybe my eyes were conditioned on the rate needles, that's why I didn't feel them.

EISELE — When you're in tight deadband and you go to the G&N gimbal test where it throws them from plus 2 degrees to minus 2 degrees, it moves the spacecraft enough so that it actually triggers the jets.

SCHIRRA Oh, it will. While it is in MTVC, just milk it. Don't fling it around or it'll damp you. The gimbal trim thumbwheels are pretty good. I woul wouldn't change them.

6.3.3 DELTA-V Remaining Counter and Thumbwheel

SCHIRRA I guess the trouble might be in this. There isn't any thumbwheel. It's a rock-a-switch and that worked fine, other than the 90 000- foot anomaly that we mentioned earlier.

6.3.4 SPS Thrust Direct Arm Switch

SCHIRRA I didn't even use it.

6.3.5 Direct Ullage Button

SCHIRRA I didn't even use it.

6.3.6 Thrust On Button

SCHIRRA Of course, we used it for all SCS.

6.3.7 SPS PC Indicator

SCHIRRA I finally got to see that on the second burn. I didn't get to see it on the first.

CUNNINGHAM I don't even think I looked at it.

SCHIRRA Actually, I didn't see the big spikes that everybody said we'd see. But you may not, because it is a baseball bat hitting you. That spike is buried in all that. You don't see anything.

hanging on for that ride. From zero g to one, wow! It will show on the TM.

6.4 Reactor Control

SCHIRRA All go, but for that one thing we discussed.

6.4.1 SM/RCS

SCHIRRA I didn't see anything wrong, other than the fact that gaging apparently did not follow the ground at all. But we did notice we could look at the temperature and see the effect of gaging. If one was off a lot, the temperature was different from the others.

EISELE The temperatures were all practically identical anyway.

SCHIRRA One was supposed to be the highest - D. We lost right away. D gaging didn't work.

EISELE Well, the quantity indicator didn't work.

SCHIRRA By gaging, I meant quantity.

6.4.2 CM/RCS

SCHIRRA The temperature on the CM/RCS thrusters never came down below 5 volts.

EISELE I think we got a few 4.9's early in the flight.

SCHIRRA We guttered that right from the beginning, because we never used it, and I didn't want to take out a checklist I'd call an emergency procedure.

I think that's fine, because it was designed not to have to be used. They found a way they could be.

6.5 Electrical Power

SCHIRRA — What are we going to do about the battery charger? That's a NO-GO, I'd say, for a lunar mission.

CUNNINGHAM — Well, there's a couple of things you can do about the battery charger. First, they will get our battery charger back so they can take a look at it and find out if it was an anomalous battery charger, or if it is really a systems problem.

SCHIRRA — They were trying to make burns without using the battery, and I think that should be looked at.

CUNNINGHAM — Definitely.

SCHIRRA — We almost proposed that in flight ...

CUNNINGHAM — When Wally saw that I was concerned about the state of the batteries that were just really dropping off fantastically, he started asking about turning it off for the burn, or even turning it on and taking the transient and determining ...

SCHIRRA Bring the gimbals up, that's a big load. You get them all up and then you turn it off. We have the gimbals on the line. We're about 4 minutes before the burn. We're already occupied. You start the count at 5:30. I wouldn't want to compress that.

CUNNINGHAM At about four and one half minutes, the bus ties come on. From that time on, they are taking a certain part of the load. It is kind of interesting because of the low state of charge in our batteries - and they weren't carrying their share of the load, battery bus voltage - currents, remember, I said it should go up to about 8. And I don't think you ever saw it over 5.

SCHIRRA What I'm getting at is this test can be done on the surfacr of the earth. It is not something that you have to go into orbit to check. You don't have to run an engine either. You just bring the gimbals up and run a careful electrical analysis of the whole system. That is why I didn't really make a big scene about it in flight later.

SCHIRRA These are the kinds of things that are going through our minds because when I had that AC 1 AC bus 2 thing, and then the batteries had gone down, I was thinking damn, if I can come in direct/direct, I may be out in the Toulies, and how's my recovery posture? So all these things are going on, and so that's why I was on this subject.

REP Well, they wanted to do some - that last charge you did was basically research charge, trying to get some better knowledge of the whole system; that was the only reason ...

CUNNINGHAM But that was research for the battery charger. It wasn't done because we wanted energy in the batteries.

SCHIRRA We were sitting up there watching our battery profile just like we were watching fuel profile, and we called for it.

REP They had that all computered out, and they figured the worst that could happen if they did that would be you would to lose that battery; but if you did, they had all the margins plotted in on a RCS hybrid which still had 18 hours recovery time.

CUNNINGHAM I'll tell you a ramification that I didn't go into yesterday, and that is that you are supposed to be able to sustain a battery failure and still continue. With that battery charger having minimal performance, I really question that capability because if you end up with two batteries, you're going to end up with a lower main bus A and B voltage than we had. We were cutting pretty close to where you would want to say, "Gee, I don't know what the hell is going on in that computer."

SCHIRRA Well, that's the thing; that's what had us scared, too.

CUNNINGHAM So, if you lose one battery -

SCHIRRA We were gun shy all along on those buses.

CUNNINGHAM That's right. If you had batteries that you recharged up to 40 amp hours every time you'd lose one, you'd throw two 40 amp hour batteries on. You wouldn't be in too bad a shape, because you'd still be close to 40 amp hours.

SCHIRRA Walt, in defense, the other thing is that we discovered quite late that the batteries weren't holding up, and that was a real nightmare.

EISELE That was a real crisis.

CUNNINGHAM We know those batteries have never failed with less than five charges on them.

SCHIRRA I'm sure that everybody was aware of the problem.

EISELE Yes.

SCHIRRA I guess we were hair-triggered in this sense: all of a sudden, people were getting confidence, but ours wasn't so high; we never really had supreme confidence in this bird. We've been really scared up there with those damn buses going off, and we weren't sure that couldn't happen again. I've never had a comfortable feeling about EMI in this spacecraft. There have been all sorts of ghosts. We've been scrupulously careful about running up telemetry in block all the time.

EISELE I listed our instances of EMI already.

SCHIRRA Oh, you did?

EISELE Yes.

SCHIRRA Good. The service module supply valve - Walt, and I have had a real go around on that. On re-entry, we turn the PLSS valve on and the service module supply up, and both must be done.

They are really a bitch to get to, particularly in this case where we are really cinched in and strapped.

CUNNINGHAM Tank pressure and quantity indicators worked as expected. There was one time when the surge tank pressure fell, and that was when we were deliberately filling the PLSS tanks; the occasion was replenishing after use of the oxygen masks. It worked as expected, replenished very quickly; the surge tanks pressure built up rapidly, and we isolated the PLSS tanks again. Tank heaters worked fine by all onboard indications. The oxygen pressure indicator switch, the one time shared ones, were fine, switching back and forth between the surge tank and tank 1. In all cases, the difference between the tank pressures and the surge tank pressure was compatible with the flow indication that we had available on the circulating fan switches. They worked as advertised. Apparently, the only problem was the glitch when the pressure switch would turn off the oxygen fans. After the problem was discovered, the remedial action was, as mentioned earlier, to operate the O_2 tank 2 fans in the OFF position nominally and occasionally stir them up by going to the ON position for 3 to 5 minutes.

CUNNINGHAM Continuing with electric power, main bus A and B fuel cell connect switches and indicators worked as expected. There were only two times during the flight that we actually open-circuited fuel cell 2; one was about 163 hours, and the other one was just a couple of hours prior to deorbit. Switches worked as advertised, including the master alarm coming on when you hit the RESET switch; perfectly nominal operation. We used the pump switches before the fuel cell pumps, I assume. There was one actuation of the fuel cell pump 2 switch; I did that, and the first time I noticed fuel cell 2 having a high condenser exhaust temperature, I just reached up and flicked it off and on, more out of curiosity than anything else, I guess, to see if I noticed a glitch on it. I was just kind of temporarily wondering if the pump was really putting it out. At the time, I wasn't in contact with the ground, I don't believe, and I hadn't had a readout yet on whether the radiator outlet temperature and radiator inlet temperature for the electric power system was

coming together or not; apparently, they were working just fine, so I didn't mess anymore with the pump service.

6.5.2 Battery Charger Switch

CUNNINGHAM — Battery charger switch worked as expected. Battery charger appeared to be working normal with the exception of the very, very quick tailing off of the charge current. We apparently have a very low battery charge rate; it started out initially on all three battery charges, which is the sum total of charges done on the flight. It would begin at about two and a half amps, and in less than an hour, I noticed on the last charge it was down to about .6 or .7 amps and moved right on into .5 amps. It seemed to hold there for some period of time, and the ground had a little bit of resolution on this switch and was showing a little lower numbers than I was. We secured when the ground was showing about .42 amps, which was kind of an agreed cutoff, but the significant point here is that it very quickly got down to .42 amps; and at that time, the battery had not been fully recharged at all. The ground

apparently by integration of charge current over time kept track of how much energy was going back in the batteries, and I would like to say something about that - we will cover the batteries right here. We had a continuing update of the battery capacity, or what it was loaded to at the present time; we had seven of these updates throughout the flight. In all cases, the batteries were down from where you might have liked to have had them for burns; and for deorbit, it was within the capability of the system at all times. However, I do not believe we were ever in good shape to sustain a battery loss and then continue for a possible hybrid deorbit, for example. The problem we faced up to preflight on when to charge the batteries dealt primarily with the problem of having a battery failure and still being able to maintain enough reserves on board at all times to sustain a hybrid deorbit. In order to accommodate this, the ground subsequent to our discussion and prior to flight, apparently decided to charge battery A after burn 2, but battery B after burn 3. We did the charge after

burn 2; we ended up with 35 ampere hours in A and 30.4 ampere hours in B. After burn 3, we charged battery B back up, but at no time after that did battery B ever exceed battery A, even though it was charged later.

EISELE I was pretty disappointed in the ampere hour readings we got on those things after charging them. I rather thought that we would get back to pretty close to full charge, and it didn't even approach that ever on either battery.

CUNNINGHAM That's right.

REP Did you think there was any inaccuracy in the charging meter?

EISELE Well, no. The ampere hour readings we got from the ground - all we could do was read that. I'm just saying the numbers they gave us compared to the normal 40 ampere hours you could expect from a full battery.

CUNNINGHAM Yes, the battery charger just doesn't put the juice back in that it is supposed to. It's going to be very interesting to see the results. They take those batteries postflight, Donn, and they'll discharge them on the bench and find out how much they get out of them. It's going

to be kind of interesting because they are nominally rated 40 amp hours, but they are probably 50 amp hours; we were dealing with a 40 amp hour number. I would like to stress here, at this time, that several different people got together including the EECOMM prior to flight, and we agreed on some ground rules for when to charge the batteries and how to do it. This was presented to George Low, and I believe he bought it 2 days prior to flight; we did not conform to those ground rules; I won't go into them here. If we need to, I can haul them out; I believe I still have a copy of them. The batteries themselves being in a low state of charge left us with less than desirable main bus voltages for the burns. Although it was adequate, it was still lower than we had expected for the many months of training prior to that. The most significant aspect of this battery charging battery capacity problem is that when it came time to do the CM/SM SEP - and at that point we don't have anything else left to do; we just got to SEP and re-enter - we immediately got a main bus A and main bus B

undervoltage. At that time, I was monitoring the main buses; we hit the separation, and the main bus voltage went down to about 25.2 - 25.3 something like that on both main buses. I can't guarantee that a quick transient hadn't gone any lower than that, but we didn't - there was not a thing we could do about it at the time. Donn expressed some concern about the G&N system which was key at this point, and since we had battery C tied in, there was not a thing we could do, and we watched the caution and warning lights glow yellow the rest of the way in. I might mention that this was a slightly traumatic experience at this point because we hadn't expected anything like it, really. I had hopes that we would still be above the min voltage. The loading for re-entry could have been considered slightly different than nominal in that - I don't know if the preflight planning had considered having a secondary coolant loop on the line, although I had always intended it to be that way, so we had the secondary coolant pump flowing. However, we did not have any cabin fans on, and I

am sure the nominal loading for re-entry included cabin fans, so we were probably pretty close to nominal, and we still had the undervoltage. Along the subject of batteries, I guess we might mention the pyro batteries. The pyro batteries were checked several times throughout the flight; the first time, it was reading 37 volts on both batteries about halfway into the flight. Later on, it was checked several times just prior to deorbit, and I believe at that time it was sitting at about 36.8, and we brought them back on the line; for deorbit, when Donn put the circuit breakers in, we did have 36.8 volts.

6.5.3 DC Monitor Group

CUNNINGHAM — DC monitor group, that's the battery charger. Do you have anything to add to that, Donn?

EISELE — On the pyros? No, I checked the pyros two or three times on my watch, and they were always right up at 36.8 to 37 volts. They held up very well the whole flight.

CUNNINGHAM — I might add one thing to the re-entry loading. When we did activate the secondary coolant loop pump at 257 hours and 54 minutes, we got this

main A main B undervoltage. Main A was 28 volts, and main B was 27 volts prior to the turn-on of the pump. Immediately afterwards, after we had had the alarm, we were showing twenty-six and a half volts apiece on it. We reset it, and it stayed up there. I might also mention that even though we had 25.2 volts right after CM/SM SEP, the main bus voltage did creep on back up, but I think we were probably pretty close to about 26 volts on both main buses as we were getting later on in the re-entry, down around drogues and in that area.

EISELE I guess our main concern is that we might have been faced with an unguided entry at that point because the EMS had already proven itself no good; and I was worried that if we had lost the guidance system, then we would be faced with an open loop fixed bank angle type of thing, and there's no telling what kind of errors we would have had at our landing point. With the weather out there, we might have been out there for several hours before they found us, but, fortunately, that didn't happen. The G&N worked fine.

CUNNINGHAM Wonder if we can go on record for the worst weather? Copters were sitting out there at 50 feet in IFR. Okay, DC monitor group. DC voltmeter, to my knowledge, no significant errors in it, it worked fine; DC ammeter, likewise; DC selector switch, no problem.

6.5.4 AC Monitor Group

CUNNINGHAM AC monitor group, AC voltmeter worked fine; we always had 114 - 116 volts AC.

6.5.5 AC Inverters

CUNNINGHAM AC selector switch, no problem, worked fine. The AC inverters, we operated with inverter 1 to main A and AC bus 1 inverted to main B and AC to bus 2 throughout the flight with the exception of the inverter check prior to the 17-1 GO/NO-GO. Incidentally, I didn't mention the inverter check earlier with that six revs systems check we were discussing. We might want to mention the inverter check. The inverter 3 was operated for the 17-1 GO/NO-GO on both main bus A, main bus B, AC bus 1, and AC bus 2; worked fine. The only other time inverter 3 was on the line was during the secondary coolant loop test power up; it was

felt they were going to draw another 100 watts down by turning this on, and we did turn it on and run it for four and a half hours. We turned it off afterwards and never operated it again. Power control switches operated as expected. Inverter AC bus connector switches operated as expected. We had one significant glitch with the AC buses; however, it occurred more than once. AC bus 1 FAIL light - let me check the time here on when we had the AC bus 1.

EISELE The first time that happened was on my first night watch.

REP Yes. At 19 30.

EISELE Yes.

CUNNINGHAM Just reset it, didn't you?

EISELE Yes, we found out later what happened.

CUNNINGHAM We had several cases, and we didn't try to track down the trouble until we had both of them fail.

EISELE Yes, those two fans would cycle on now and then and it turns out that when they would cycle off, you'd get a momentary surge and overvoltage condition on the AC bus. It would throw it off the line, and you would get the warning

light, and you'd get the warning light coming back.

CUNNINGHAM In some places, we had several AC bus 1 fails. They were apparently anomalous; we reset it, and it worked fine. At 61 hours and 14 minutes into the flight, both AC buses failed at the same time. Both buses reset; the ground did an exceptionally fine job in tracking down the trouble, and they finally correlated the O_2 tank 1 and 2 fans going off on the pressure switch actuation as triggering the transient which gave a very, very short duration overvoltage on AC buses, which automatically disconnected the inverters. From that time on, we operated with one fan on AUTO, the other fan OFF except for intermittenly putting it ON for mixing of the CRYO's in tank 2. During the burns, I felt that in all cases, we operated with both of them off, but I can't swear on a couple whether we had them both off or not. The attempt was made to not have them on at critical times so in case it did glitch you wouldn't lose the bus. Inverter AC bus connector switches; main bus tie switches.

6.5.6 Main Bus Tie Switches

CUNNINGHAM The main bus tie switches worked as expected throughout the flight. I guess I was a little bit surprised to see that in all cases the amperage on the battery buses was slightly lower than I expected when we tied the batteries onto the main buses. This could probably be attributed to the fact that the batteries were always in a lower state of charge than we were used to seeing. Therefore, they weren't picking up as large a share of the load, and we left more of the fuel cells. The net result was that the main bus voltage was down a little bit, and we pulsed the fuel cell heating rate probably just a little bit. Going back to where we were discussing main A and main B voltages, we got main A and main B undervoltage when the secondary coolant loop pump was turned on prior to deorbit, at 258 hours and 15 minutes. We also had several others because battery voltage was running right about the trigger point, and it came on and off several times. We put fuel cell 2 back on the line and had no trouble with that until after separation. There are a couple

of isolated things I would like to mention - about the DC system before leaving it. I made a note in the log at 216 hours and 40 minutes, which just happened to be one of these periods, that current on the fuel cells for the burns - and this is just prior to the 530 when we start training to begin with — ran about 25 amps per fuel cell. When we were in drifting flight, depending on the state of the cyclic loads, it generally ran down around 16-17 amps per fuel cell. Sometimes cyclic loads would kick it up close to 20 amps per fuel cell. Another point to be covered here would be the electromagnetic interference or EMI. I have an entry in the log at 215 hours and 57 minutes to summarize a few of these things, to the effect that during one night pass or several night passes, we had tried turning exterior lights on. On this particular night pass, turning the exterior lights on and off gave an 1105 ALARM code on the computer which was downlinked too fast. Another item of EMI was the O_2 fans were glitching the AC buses, but they were also sending transients out which at one time started the DET in the

lower equipment bay. That was done when the O_2 tank 2 fan was turned on. The DET spontaneously reset and spontaneously started counting till it stopped. That completes DC stuff, I think. I can complete one more item, and then we're through with EPS. Right?

6.5.7 NON ESS Bus Switch

CUNNINGHAM — Nonessential bus switch, worked as advertised, never moved out of the AC bus 1. The non-essential bus was tied to main A throughout the flight.

6.5.9 G&N Power Switch

CUNNINGHAM — G&N power switch, whenever it came on, we put it to AC 1. When we powered down, the G&N power switch was turned off; we turned it on several times when we had not powered up the G&N in order to use the optics in the lower equipment bay. The last item under the electrical power is the cryogenic system, the tank pressure and quantity indicators.

6.5.11 Cryogenic System

CUNNINGHAM — The quantity indicators, I assume, were reading fairly accurately; there seemed to be a pretty good correlation between the ground

and on board. The ground seemed to have better resolution and was able to read down -

EISELE They had a better resolution, and I know the O_2 pressures in particular in fact, I think the hydrogen pressures were always low on board, lower than the true readings the ground had, but that didn't pose any problem. I noticed generally throughout the mission that the pressures in both the hydrogen and oxygen tended to hang at the low end of the green band on the meter.

CUNNINGHAM Very definitely.

EISELE And after awhile, we just assumed that was normal operation and didn't worry about it.

CUNNINGHAM This was consistent with data we had preflight which indicated that that was the control range in these particular instruments, but I never remember ever seeing the pressure up at the high end of the green bands except at a time when we -

EISELE We deliberately ran the stratification test up.

CUNNINGHAM On hydrogen before the deorbit burn, I put the hydrogen heaters to ON instead of AUTO, and we

purposely raised the hydrogen pressure up towards the top end. The tanks stayed balanced throughout with one exception. It took until about 167 hours into the flight to achieve an unbalance between hydrogen tank 1 and hydrogen tank 2 (which was reading at that time 3.4 percent). Rather than wait to get to the 4 percent unbalance level, I initiated the manual balancing. Manual balancing took about nine and a half hours, and when we completed the manual balancing, hydrogen tank 1 was reading 36.6 and hydrogen tank 2 36.4 percent. I may have neglected to mention that when we started, the hydrogen tank 1 was 43.2 and hydrogen tank 2 was 39.8. This data is actually included as part of one of the DTO's which was manual cyro balancing if needed.

EISELE I guess the point is that the manual technique does work very well if you do need to correct an imbalance.

CUNNINGHAM Yes, we might stress here that it can take a considerable length of time for this balance to be achieved. The cyro stratification test will be covered under the DTO's, however.

Essentially, it looks like we have little or no problems with stratification. I make no special mention of a min DQ/DM region. As long as the pressures were never running towards the high end in the tanks, I really didn't even consider it at all. It seemed to be running pretty fine, and pressures always stayed down within the right ranges. We finished up onboard readings with 14 percent for the hydrogen and about -

EISELE I wrote 29 percent oxygen. Wasn't it 24 percent?

CUNNINGHAM I don't remember exactly, but it was in the high 20's, I believe.

EISELE The point is that there were plenty of volts at the end of the mission.

CUNNINGHAM Somebody told me that we were 60 pounds ahead on oxygen by the end of the mission. Incidentally, we cover an area called consumables, don't we?

REP Donn, you want to pick up where you stopped on the moding?

EISELE We were talking about OSS moding - the zero optics mode. I was simply mentioning that we did not bother to run the trunnion angle down close to zero before switching to zero optics. We simply flipped it there and let it drive. It would overshoot several degrees and then come back to zero; we never had any problem with the optics the whole flight. I don't know how many times it went to zero, but it was, I would say, well over a hundred times. The manual modes I think I've already discussed; they worked beautifully. The thing tracks very smoothly, far better than we've seen in the simulator, which is a digital drive type of thing. The computer mode worked very well; the computer generally would drive the optics to a star very accurately. Usually, there'd be a little bit of bias or offset which could have been due to IMU slight misalignment, or some bias in the computer drive itself. It would usually drive out - say it was going to a star - it would drive out and overshoot,

means that for 1 degree per second it's about 1 pound of fuel, which is very, very expensive.

EISELE If you pulsed it.

SCHIRRA Pulsed it. I found that for any rate more than one tenth of a degree per second, it was much more practical to use acceleration command. I used RATE COMMAND only for attitude holding when we were translating if you either had ullage or were translating during the braking phases or rendezvous phases.

EISELE For line of sight measurements during rendezvous also, that's about the only time.

SCHIRRA For any other line-of-sight measurement such as the COAS alignment, pulse was the only way to go, other than when we switched from one star to another. I wanted to go RATE COMMAND there, but I had to have the cockpit completely dark, and as a result, I used the pulse in that case, but it was more expensive than I would have liked to have made it.

EISELE I guess the point is that the pulse mode is your fundamental control mode for just about anything you want to do.

SCHIRRA That's terribly luxurious.

EISELE I think that the postflight data will show that their design intention was way off what we really saw up there because that thing really cycled back and forth very rapidly.

SCHIRRA That can be avoided, though; you don't need to redesign just to -

EISELE Oh, no.

SCHIRRA People have just got to understand that we know how to fly it.

EISELE What you have to do is do your roll in pulse so that you control the roll deadband effectively by your manual inputs and not allow the automatic to do it. The other deadband modes seem to work pretty well. I don't know what the fuel usage rates actually were, but they were far less than the flight plan.

SCHIRRA There's one we should make note of, and that was the early phase of the flight where we did the yaw deadband. I got some data on that in my zip flight plan here. When we were venting (while it was working the first part of the mission), it caused us to go off to the right, yaw right, and it cycled between 7.9 degrees

yaw right and 7.1 degrees yaw right. So it actually flew on the edge of the deadband; it oscillated back and forth in that regime for a long period of time, never leaving it. I'm just trying to find out what the delta time was because it was rather surprising to stay over there like that.

SCHIRRA I think it was a minute and 55 seconds, or a minute and 5 seconds. The conditions were SCS attitude 1, rate 2, limit cycle ON, attitude MAX, rate, attitude deadband MAX, rate 5. That roll, approximately 174 degrees, pitch 349 degrees, yaw varied between plus 007.10; that's 7 hours 17 minutes 3 seconds to plus 007.82 degrees which is a delta of .72 degrees. At 7 hours 18 minutes 56 seconds, which was 1 minute and 53 seconds, it cycled back and forth, roughly between these numbers, meaning it was yawed right and rode the right edge of the deadband. The only variable that was causing this was the - this was not the perigee torque; this was early in the mission. This was caused by the steam vent water boiler combination, forward in the spacecraft. We tried

all control modes, but for the very, very high rate modes, which weren't required, they did work during the rendezvous modes. I don't believe in spacecraft checkouts for control systems, like airplane drivers like to do it. It's very expensive. You use it; if it works right, it's fine; that's rather than this classical manual maneuver in G&C control mode .05 degrees per second, .5 degrees per second and 4 degrees per second. We never at any time flew at rates of 4 degrees per second. Even the pitch turnarounds were at two and a half to 3 degrees per second. As the degrees per second go up, the fuel consumption goes up, proportionately and violently.

EISELE I think we hit every mode in there except those high rates - -

REP The TVC's, DELTA-V's, RCS and SPS interface: any problem there?

SCHIRRA No.

REP Okay.

SCHIRRA I believe we were right in our preflight decision of not checking out the command module RCS thrusters, both from a time-line basis and

from a real-time observation that we had propellant right up to the thruster solenoids. There's no doubt in our minds that that even occurred.

SCHIRRA Did you make remarks on the DSKY? I talked to Kenny on the phone. I felt that the DELTA-V counter display numbers, the DSKY numbers, and the mission event timer on the MDC all were subject to fadeout with bright sunlight on them, and they were not readable -

EISELE Yes, that's right.

SCHIRRA - and that some type of cover, sun cover, should be provided. I would suggest that Frank Borman work that out himself without having a whole bunch of engineers get in the middle of the act, and I'll make that evident to Frank, what the problem is.

EISELE Yes, you might -

SCHIRRA The first real realization we had of this problem was not being able to read the DELTA-V counter during number 5 burn. With that continually in drifting flight, we couldn't read the MET -

EISELE The MET seemed to be the worst offender.

SCHIRRA - with the numeric switch full bright, I might

add. On occasion, we couldn't read the DSKY when we looked down below; I didn't, anyway.

CUNNINGHAM On the DELTA-V counter, we had G&N monitoring. That was a G&N burn when we took over, wasn't it? When we took over manually, was the DSKY still counting up that DELTA-V?

SCHIRRA Oh, sure. That wouldn't shut if off.

CUNNINGHAM I was just wondering if that one was visible at the same time, a little different sun angle.

SCHIRRA It was. Well, I couldn't look at it first. Burn 5, you mean?

EISELE Yes.

SCHIRRA Yes, but the shutoff was depending on the DELTA-V counter. The DSKY is not sufficient for cutting a burn off manually.

EISELE It only updates every 2 seconds, and 2 seconds is a lot of feet per second.

CUNNINGHAM In 66 seconds, it was only 1600 or something?

SCHIRRA It's roughly a 1 g burn, so we only burn another 60 feet per second on top of that.

SCHIRRA The most glowing tribute I can give is that as far as I can tell, except for that hand-controller anomaly — and I'm positive it was the handcontroller — there was not one faulty thruster for the duration of the mission including CM and SM RCS and SPS. That's a big thruster!

EISELE Yes.

SCHIRRA Which is quite a tribute to anybody's propulsion system.

EISELE Yes.

SCHIRRA I think that's really a first.

EISELE Just discuss the rotation handcontroller.

SCHIRRA We did try direct/direct, and the technique there is to take the stick all the way out to the soft stop and just blip from that, and you can get a short pulse of about one tenth of a degree per second which is sufficient to back up a pulse mode, or I think it is usable for a re-entry, but as you get g on, it's a very difficult task. This is merely coming up with the feeling that the soft stop is tough and then just go along a little bit and watch the result of this, rather than feel it or hear it.

I guess we ought to describe the sounds of these thrusters. Donn, I think, felt that the best description is much like a man hitting a steel drum like the Bahamian bands, the steel band; and oddly enough, that analogy is quite good because pitch and yaw have different tones.

EISELE Pitch had one note, and yaw had a note a little bit higher in frequency sort of like a bong, bong, bong, bong, and roll was a thud; it was a very dull -

SCHIRRA Yes.

EISELE Esthetically, roll wasn't as good. I was talking to George Page this morning, and they were all concerned about the audibles on the pad.

SCHIRRA I told them we had those thrusters on. We heard them.

EISELE I thought it was significant that they were much less noticeable there on the pad.

SCHIRRA Than in flight.

EISELE Than in flight.

SCHIRRA Yes.

EISELE And, in fact, you have to listen pretty close on the pad.

SCHIRRA I think that's because they're insulated, and the sound was masked by atmosphere as well.

EISELE They were wondering what degree to go to make sure the cameras were on thrusters, and I felt we would still have to verify them on TV.

REP We were talking about control ... rotation translation, different modes here.

CUNNINGHAM Well, our preferred mode was PULSE and an occasional ACCEL COMMAND input and, on very rare occasions, using RATE COMMAND.

SCHIRRA I'd like to throw in a note of caution. I've talked to McDivitt and Borman about it for the record. The most colossal goof you can walk into - I had to learn that once - is to leave the BMAG in ATT 1 rate 2 and then switch back into them after you've maneuvered. So you want to go to the last place you were caged up at. That thing will really hum. Fortunately, you're only about 2 or 3 degrees away, but that spacecraft just went WHOOOOOM right into it. It takes all the authority it's got in the system and just fires all thrusters and goes there. That's a very luxurious mistake. So that's the kind of goof you have to really

watch for so that whenever you leave a precise attitude that you've been trying to hold with that thing with the BMAG's in BMAG rate 1 or rate 2, you get out of that attitude hold mode. It's a very dangerous thing. Another problem we found was switching from PULSE to ACCELL COMMAND. Unless we switched rapidly through RATE COMMAND position, which is between the two, you get RATE COMMAND lock-up, meaning that you would stop the rates you had, either from ACCEL back to PULSE or PULSE to RATE COMMAND. This would waste your fuel, but you could set up a rate you wanted, and maybe you'd want to stop it with PULSE or ACCEL COMMAND, just reversing the modes. Going through RATE COMMAND, if you went slowly, you'd stop at RATE COMMAND; that got expensive. You might not want to stop it; you might want to increase it. Ideally - and that's for future design; I wouldn't change it in any of the command modules - RATE COMMAND should be on either end, not between the two modes. It's not a major crisis; it's just something that ... technique hasn't been thought out too well. I can't

fault the SCS other than those minor criticisms, and I call them that except for the handcontroller malfunction. That bothered me to no end because that first appeared to ruin our hybrid deorbit. I could have used that anomaly - pitched down and swapped handcontrollers and used that as a pitch-down mode.

EISELE Yes. ... that's what we talked about doing, in fact. We finally concluded we really hadn't lost the hybrid.

SCHIRRA So we really hadn't lost the hybrid in that sense. Just had to turn the handcontroller on to get a free pitch down in ACCEL COMMAND; just turn that handcontroller off if we want to stop it. So we'd always maintain a hybrid deorbit even with that anomaly, assuming it came up again. The way we'd lose hybrid deorbit is to lose those two AC buses. That was all academic.

EISELE Translater seemed to work fine; we didn't have any problem with it.

SCHIRRA Never.

EISELE In both G&N and SCS. I don't know what this means, automatic. We didn't do any automatic maneuvers in SCS; all it can do is attitude

hold. It does that very satisfactorily. That minimum deadband is a very nice type deadband. It's very useful for things like line-of-sight measurements in rendezvous and also holding a precise attitude just before an SPS burn, but it's also a very expensive mode. One thing we noticed - this is to a degree subjective because it was kind of hard to measure on board, but it seemed that the limit cycle switch didn't really help all that much, particularly in this tight deadband configuration. The limit cycle is supposed to cut down the number of firings, the frequency of them. It didn't seem to make much difference whether it was in or out because the thing in tight deadband would cycle rather rapidly and roll back and forth. You'd get a pulse every few seconds, and it would drive to the opposite side of the deadband, fire another one, and come back. You could get around this partly by trying to set up a single jet configuration. If you push and pull the right combination of circuit breakers -

SCHIRRA Can't do that. You have to go into ACCEL COMMAND to do it.

EISELE Yes.

SCHIRRA The only way you can do that is to turn the roll attitude hold off and use PULSE in that mode, in that attitude, in ROLL. That's what I was complaining about in flight. It's very expensive to hold attitude in SCS minimum deadband, limit cycle OFF, minimum deadband, low rates. The roll would - well, attitude very technically would pulse back and forth at the rate of two tenths of a degree per second, holding this very tight deadband on a two-tenths of a degree roll attitude. That's terribly luxurious.

6.6 Environmental Control

6.6.1 Oxygen Subsystem

CUNNINGHAM — In general, we can state that the oxygen subsystem and environmental control system provided excellent service throughout. The only possible anomalies that existed were associated with the O_2 flow high. I say possible anomaly because in almost all cases where the O_2 flow went high and we had a caution and warning light, we could track it down to something in the spacecraft. About 99 percent of the time, it was the waste management dump valve being left open after a urine dump.

SCHIRRA — Let's explain why that was, Donn, because it is a trap. Our technique was to vent the urine line with the same device we used to enrich the cabin. Yesterday, I talked to Kenny and recommended that it be put on the spacecraft for all subsequent flights as a vacuum cleaner. I couldn't think of a better way of vacuuming than that device itself. You could optimize a little, but I'd rather not go into a big design program; just leave it like it is.

CUNNINGHAM — They've got a 90-degree elbow in the thing that I would just as soon they didn't have. There is

a 90-degree elbow when you start vacuuming.

SCHIRRA It was just right for me to vacuum with frankly. I would go down that pipe and all that sort of stuff, and it worked fine. But I would rather not redesign something if it does do the job, just tell Kenny it's satisfactory. If you disagree, let's get that point out in the open.

CUNNINGHAM It's not that significant. I felt like it was an off the shelf item.

SCHIRRA That's what it's supposed to be.

CUNNINGHAM They picked that one up in, — like a day. I suspected that they had one without a 90-degree elbow in it that they could pick up the same way. I would rather see a straight one than a bent one.

SCHIRRA They needed more length; it didn't stick up in the cabin too far.

CUNNINGHAM That's right, because they figured that most of its use would be sitting over there in the waste management panel, and most of its use is really sitting on the end of the urine dump line.

SCHIRRA I guess that was a lousy place to stow that; you had to go to 1, 2, 3, 4 places to go through a urine dump procedure.

CUNNINGHAM You're right.

We should not have left that little valve there temporarily. It should have been over on the right hand where the tape was.

SCHIRRA Yes, I don't know why we didn't move it over there. I thought of doing it once or twice; I just got in the habit of backing off. We should have stowed that thing temporarily -

REP Where the tape was in the tape compartment.

EISELE That little triangular box where the tape was stowed?

CUNNINGHAM That's where we should have left that little vent thing.

EISELE Oh, you mean when we weren't using it?

CUNNINGHAM Yes, that would have been all right.

Getting on to the anomalies: very early in the flight, we had the O_2 flow pegged high for a significant period of time; I think it was about 5 to 6 hours in flight. The ground seemed to think it was a transducer problem. Onboard very shortly thereafter, we had discarded this possibility. The O_2 flowmeter, as far as I am concerned, reflected accurately what was going on with the O_2 system throughout the flight.

The Delta-P between the surge tank and the oxygen tank pressures always correlated with the flowmeter when the flowmeter was less than pegged.

SCHIRRA I would like to make a point here and get this down once and for all. The ground doesn't realize how much that flowmeter means to us. It's a very valuable piece of instrumentation. They don't understand that that is valuable. In checkout where they had hard line in the spacecraft, the ECS people here knew how valuable it is because they are on it all the time. They would warn us when they were going to get an alarm (which was very good head I thought because we were busy at these other times), so we weren't surprised. But Range doesn't understand how important that particular instrument is to us. That's your cue to all sorts of crises in oxygen.

SCHIRRA Yes, it is.

CUNNINGHAM Yes, I've been begging for that thing for a long time. Along this line, something I recommend in a memo to Deke about 2 months ago is that we should get a flowmeter which goes higher than 1 pound per hour.

SCHIRRA I remember making that when we hit up with the enrichment thing.

CUNNINGHAM Yes.

SCHIRRA There is one coming on the next spacecraft, I believe.

CUNNINGHAM I don't think it's in. I recommend that they be made in line, and the reason for it is that there are certain components in the spacecraft which when they fail to open have fixed flow through them. For example, the cyclic accumulators; I'll leave that as one example. When you take and superimpose the cyclic accumulator failure on top of say the first 6 hours or 12 hours of flight where you are bleeding the cabin down, you got a flow rate of about 1.3 or 1.4 pounds per hour. We have a meter that's pegged and you can't do much with it. As far as reading it, you have to try to correlate between a Delta-P of a surge tank and the oxygen tank and its not very acceptable.

SCHIRRA A specific case is the enrichment thing for through the urine dump. It happens to be

somewhere between .6 and .8 pounds per hour. If you could read 2 pounds an hour, you'd cover most of these contingencies.

CUNNINGHAM I don't think I would recommend changing the caution and warning limit. I think it is significant to keep it right where it is. The way it is now, caution/warning comes on when the meter pegs, and you don't know anything.

SCHIRRA In contrast, I would discourage changing that limit.

CUNNINGHAM That's right.

SCHIRRA Because that's how we are reminded to go down and turn the dump off.

CUNNINGHAM That's right.

SCHIRRA Wonder how many times we forgot to do that.

CUNNINGHAM We sit here and laugh about it, but everybody should understand that after 11 days of it -

SCHIRRA We were still doing it.

CUNNINGHAM We were still doing it, and this was after we swore — I know I took secret oaths to myself not to goof the urine dump system, and Wally and Donn would turn around and find a step out. It got so bad that I made a checklist. I wrote it down in my log; I wrote the checklist down, and

when I got through, I looked through it and I had left a step out of it.

REP This is the urine dump procedure?

CUNNINGHAM That's right.

REP Urination procedure.

SCHIRRA Probably the only place we saw oxygen problems other than those early anomalies — I still don't know what the heck -

CUNNINGHAM That's right. I said most of it was traced to this waste management system. I think we still have some possible anomalies existing.

SCHIRRA The ground was saying that we had a failed sensor. I don't believe that on analysis. This goes back to my original thesis —

CUNNINGHAM I talked to John Aaron on the phone about the ECS, and he said, "Hey, I goofed that one."

SCHIRRA As it turned out, they did the same thing to me in Mercury. They goofed my suit temperature. When you have a gage and the needle moves, the needle responds to delta's, the gage, or the sensor hasn't failed. It may have shifted, but it hasn't failed. I think we all ought to learn that TM is not as good as a needle and analogue; TM is digital.

REP In general, I think we were all quite happy with the oxygen system.

SCHIRRA I guess that ought to remind me to remind FOD that all meters are analoged. They don't have anything analoged on the ground.

CUNNINGHAM Wally, why don't you bring up the service module supply valve?

SCHIRRA The service module and PLSS valves and where they are located: for future spacecraft, please don't have the poor command pilot running the ECS. That's a big mistake. I had to worry about dumping the cabin during boost in case the cabin relief valve didn't close. I was strapped in in a tight position toward reentry. I found I couldn't get to the service module supply valve which was called OFF after retro and I turned the wrong valve. I looked over there again and could just barely see it; it didn't have a bubble on it, or I probably wouldn't have seen it. I had the wrong one on; I called that out, went back and got the right one, and turned the other one back on.

REP The PLSS valve, the service module supply valve? And you got some reservoirs right behind it.

That's where the valve is. Three in a row there.

SCHIRRA I never used it. Three valves in a row: PLSS, service module supply. Tell me what I'm thinking -

CUNNINGHAM Surge tank?

SCHIRRA Surge tank valves. Yes. All three are difficult to turn, and they are almost impossible to see and after CMS; no, actually after retro. It was called out for me to turn off the service module supply, and I reached over there almost blindly, turned off the surge tank which is wrong, and just out of the corner of my eye, I could see it again, so if I had had the helmet on, I probably wouldn't have seen it. That's not an excuse for having it off, but as a result, I could see it; I struggled like mad in this tight restraint, and I got it back on again. I was really grunting and groaning, and then I got it off again. I got the surge ON and the service module supply OFF; they are difficult to work. Something else that we didn't have happen to us and didn't have available to us - I might add as long as I'm over in that area - we talked many times about a swizzle stick to get to some of

those circuit breakers. I did not have it, and I still don't know what I would have done if I had had to run some of those circuit breakers in a hard suit.

CUNNINGHAM I had exactly the same problem on the right side. I think one swizzle stick would have done the job if we had had one.

SCHIRRA Particularly for a one-man command module operation, this is a real big requirement. I think the swizzle stick should be required for the next mission, and if they do have to ride a hard suit, they're going to have to run some of this stuff.

CUNNINGHAM Incidentally, while we're on the subject of the swizzle stick, I sweated throughout my training getting on the panel 275. After you get on the chutes, you've got three circuit breakers to push in and two circuit breakers to pull out. You do it completely blind. I had a pretty easy time of it because I didn't have my gloves on. I really breathed a sigh of relief. With the gloves on -

SCHIRRA Let me ask you why we were doing this. We were doing this really to protect ourselves from an

inadvertant chute separation.

CUNNINGHAM No, no, not this one; those are two other circuit breakers. We're doing this to keep the batteries from being drained down by the main bus. You also have open circuits sitting still on the main bus that you just want to get cut off before you hit the water.

SCHIRRA It's all "What if," though. You can get in a dangerous mode.

CUNNINGHAM I think there are some things - it's not a lot of trouble maybe, but it's like your gimbal motor control circuit breakers. They're not deadface both sides where they run through the service module.

SCHIRRA The system was designed so that you shouldn't have to do that. That is another backup deal that could put you into a dangerous mode in the first place if you did the wrong circuit breakers, could it not?

CUNNINGHAM You could end up with less than all your power being on the right bus.

SCHIRRA Post landing.

CUNNINGHAM Yes.

SCHIRRA Then it's no problem; you can look at it. After

landing, you should look at it and reaffirm your positions.

EISELE — Yes. I did, incidentally.

SCHIRRA — I did, too. Before I got out, I went over and looked at it. Enough on that subject. Oh, one thing we did have happen, and I'm not sure where it's going to come up in here. We ran the PLSS down -

CUNNINGHAM — I was going to mention that right here, the PLSS valve under section B.

SCHIRRA — That's what I was trying to get at; that's why I'm here. When we tried out the emergency O_2 masks, one mask triggered off on the test button, and that caused the O_2 mask to flow. The only proper way to stop it is to put it on your face and breathe against it, which we tried out in the altitude chamber. I guess Donn was down below, and he triggered some kind of funny stuff. It lowered the PLSS tanks, and after that, I just refilled the PLSS.

CUNNINGHAM — The PLSS went down at that time to around 800 or maybe a little bit less.

SCHIRRA — Less than that.

CUNNINGHAM — We threw the surge tank on the line; we put the

PLSS valve to FILL. The surge tank dropped immediately down to about 850, and in a very short time, it built right back up, and we isolated the PLSS tanks again.

SCHIRRA Frankly, that was a DTO we hadn't anticipated flowing, and it worked fine.

You could hear the PLSS recharge. That was interesting; I didn't expect to hear it. Did you expect to hear it?

CUNNINGHAM No, I didn't.

SCHIRRA It's a very audible noise, swir-r-r-r-rear.

CUNNINGHAM That was the balancing of pressures; yes, I heard that. When you put the surge tank on, you immediately heard them going together.

SCHIRRA The PLSS and the surge manifold together.

CUNNINGHAM That's right, but we flew with the PLSS valve OFF throughout to keep the two systems isolated, the two onboard command module oxygen systems. Recognizing the fact that had we had to support a slow leak in the command module, we would have had to go to the FILL or ON position.

CUNNINGHAM On all of these things, I can - surge shutoff valve. It was operated once inadvertantly and opened back up again. Surge tank pressure relief valve was never utilized. No. We used

the emergency O_2 valve with the mask. The repress O_2 valve was never actuated.

SCHIRRA No.

CUNNINGHAM We don't want to use that.

The main regulator valves operated normally throughout. We checked them on each redundant

component check; they were always running between 103 and 105 psi for O_2 manifold pressure. I'll cover the redundant component check separately probably under this section. There are some changes we made in flight on it. Water and glycol tanks pressure regulator, no comment. Water and glycol tanks pressure relief valve, no comment. Neither one of these valves were moved throughout the flight. Apparently, the emergency cabin pressure regulator worked fine on the redundant component check. The cabin pressure regulator - the cabin pressure was regulating at the high end of the band of the control area; however, it was normal for our spacecraft. We knew before the flight that it would be operating between 5.2 and 5.4 psi. It did so very satisfactorily. On the numerous occasions when the waste management drain was left open, it would slowly bleed down the - and the demand reg kicked in and ran it right back to 5.4. I'd say it was a very tight cabin because we almost never had flow except after we had bled it down.

REP They tell us it was less than one tenth pound per hour.

CUNNINGHAM Is that right? I just had an intuitive feeling that it was a pretty tight cabin because it was always reading 5.4.

SCHIRRA I'd like to add item 7 hygrometer readings. I'd like to get that knocked off on future flights. That's nowhere in the rest of the books. Walt's got the readings. We never called them down to anybody; they just stayed right in the books.

CUNNINGHAM Right. Why don't I just summarize it?

SCHIRRA I'd like to recommend that we not do that on subsequent flights. It's a waste of time. We did it all the way down except for the very last one because we wanted to stow it. And everybody bought stowing it.

CUNNINGHAM We had a whole page that falls in the same category as the gas analyzer, a good one shot deal, just so you understand this.

SCHIRRA So, I'd better get down and get that audiogram right now.

REP What did you ask me about. . .

REP We got get those in the loop, I don't think we should hold them.

... . I don't want to just turn them loose and let a year or two -

... . the right guy is going to want those and it should be lab work and I think they should get the darn readings.

... Yeah.

... Okay.

SCHIRRA I'd suggest you call Donn and see if he is going to come over tomorrow. I agree with it his not being here now.

6.6.2 Water Supply System

CUNNINGHAM I'll continue with the water supply system. Waste tank inlet valve was not moved throughout the flight. Portable tank inlet valve was not moved throughout the flight. We did take off the cover on the waste tank servicing valve and attach the waste water dump fitting. The valve itself was actuated. The ground can check back on how many times we did dump waste water. I have a recommendation on the waste water dumping. They got quite concerned about dumping when it got to about 85 percent and wanted us to knock it off at someplace around 25 percent. It was fairly obvious to everyone on the ground that

we were trying to push this off and not dump it until we got up to 90 to 95 percent. We ran it down to a little bit past 25, then down to the 10 to 15 percent meter reading on board. I'd recommend that we go ahead and continue to dump over a longer span so we don't have to do it any more often than necessary. The procedure itself - even though we had a flexible hose that was running across the cockpit - was really a piece of cake. It was one of those little tasks that was like a lot of the others; you had to watch it pretty close to cut it off.

EISELE That is one where the little alarm clock would help. You could set it for 4 minutes or 8 minutes, whatever you determine dump time ought to be, to remind you to turn it off.

CUNNINGHAM The time we got down to 10 percent there were two of us doing the task and two of us watching it, and we still had enough things going on where we got down to 10 percent before we shut it off. It's not catastrophic, however. The evaporators could always pull water from the potable water tank. The attachment that went on the waste tank servicing valve had a swage

fitting, and we tightened it up as much as we felt we ought to with that great big wrench; yet it still continued to leak a little bit of water at the fitting, which we had to vacuum up each time when we got through.

EISELE At the end of the dump, you'd have a spherical glob about the size of a 50-cent piece hanging onto the fitting.

CUNNINGHAM It was just another source of water in the cockpit and another task to clean up, and we should probably try to get some kind of a better fitting there if we're going to use it. The fitting itself interfered with B8 where we had an awful lot of 16mm film stowed on this flight. We ended up taking all the film out and leaving it in temporary storage - which is like 8 or 10 film packs - and then only putting it back in at the end of the flight. There's a definite interference problem there, and that valve should be shorter - excuse me, the attachment should be shorter and probably come out at a different angle.

Pressure relief valve. That's probably the water tank pressure relief valve. To my knowledge, it did not operate. Chlorine injection port.

CUNNINGHAM There was one onboard problem with the chlorination. It was the third chlorination of the water. And the LMP was conducting the chlorination. I placed the chlorine ampule in the chlorinater, attached it into the bayonet fitting, and turned it. Apparently I did not turn it far enough, and it just barely caught in the bayonet fitting. When I made the first turn between that time and the time that I operated it, it slipped back out again. I just felt it. It wouldn't pull out, so I assumed it was in. I made one turn on the cap, and I could see chlorine solution oozing out down around the bayonet fitting, using a flashlight I very quickly determined that I had not seated the thing all the way over. My recommendation is to make sure you visually see the bayonet attachment go all the way over. If I hadn't been watching, I could have cranked that in, and it could have put the whole business out. In zero g the chlorine solution doesn't come out and just fly away.

REP It does not disperse, but tends to hang in space?

CUNNINGHAM It stays right there, but we did have a chlorine problem to clean up. Several droplets did float free. We're still concerned about the chlorine being loose in there.

EISELE I think it just highlights the hazard that you do have with the chlorine solution being in there in the first place. It can leak out and cause you problems.

CUNNINGHAM The water started tasting bad when we were chlorinating every day. After the third day, we made an effort not to drink for an hour or so after we chlorinated the water. In order to chlorinate, we had to drink down about 8 ounces on our potable water tank. I still have some doubt as to whether this is enough to drain. I mentioned this to Wally when we first tried it. We had a potable water tank that was full, we had to chlorinate, and we had to get some ullage volume in the tank to get this mixed. We should have been indicating 93 percent or less in order to be sure that the chlorine that we put in was getting down to the ullage volume. Then it would get mixed up, because it comes in and goes out on the

CUNNINGHAM same line. I would like to be shown that the recommended amount to be drained out, was sufficient. That could be the reason we got the bad taste in the water so soon. After the third straight chlorination of 3 days in a row, Donn took a drink from the water gun an hour at least after we chlorinated, and it almost made him sick. It was apparently too strong at that time.

EISELE It was pretty bad.

CUNNINGHAM On this particular day, the water still did not taste good 10 or 12 hours later. It was not refreshing. Going to every other day chlorination, the water tasted better. I hope we got a good analysis of the water postflight. I definitely recommend, and I think everybody concurs onboard, that we don't chlorinate any oftener than every other day. No problems with food preparation, as substantiated by some of the onboard movies. We used three different sources of water for food preparation and we dislike all three. The drinking water gun had more gas in it than either of the other two sources of water. You could get some very good

CUNNINGHAM water, and then all of a sudden one pulse would come through of gas -

EISELE You'd get a mouthful of gas coming through.

CUNNINGHAM That's right. Using the gun with a food bag, you'd have a full food bag that wasn't full of water. We found ways of getting the air out of the food bags. It's something that we all ought to talk procedurally to the subsequent crews, and save them a couple of days learning time. The cold water tap that was used in the cold water valve had next to the largest amount of gas in it. The hot water had the least amount of gas.

EISELE It had hardly any.

CUNNINGHAM I could hardly move the trigger on the water pistol by the tenth day. The cold water tap was getting somewhat the same way. It would stick back. It just didn't want to work as smooth. It wasn't near as bad as the water gun, but it was getting harder to operate.

EISELE It would hang up a little.

CUNNINGHAM The hot water tap worked fine throughout the mission. The hot water is absolutely the greatest thing we've had. There was plenty of

CUNNINGHAM hot water. We were never short and it was always very hot. When we had to let some of those meals sit for 15 minutes, they were still warm.

EISELE We could run all three of our meals - the hot water dishes, and the temperature did not drop off at all, that I could tell. We also used it to clean up. You could take the clean towel and hold it up by the spout and squirt several shots of hot water on it.

CUNNINGHAM Incidentally, you had to take a clean towel and hold it right around the spout because the spout's got the water coming out of the side.

EISELE You have to be a little careful that you don't squirt water all over the SC.

REP Was the taste of the cold water good, and was it cold enough?

CUNNINGHAM Yes, except for one day.

EISELE Toward the end of the mission - the chiller apparently ceased to function.

CUNNINGHAM That's right, I felt it did.

EISELE It was not near as cold and refreshing as it had been earlier.

CUNNINGHAM The water when it was cool tasted good and very refreshing. About the ninth or tenth day there was about a 24 hour period when it became warmer. Then it seemed to get cooler again.

EISELE Yes.

CUNNINGHAM About the tenth day, the water gun started getting a kind of "garden hose" taste a couple of times.

EISELE Yes, I noticed that.

CUNNINGHAM We were all quite happy in general with the food preparation. The gas was a problem, and we ought to try to do something about - if there is a way. The drinking water shutoff valve was turned ON when we got in orbit, and turned OFF for de-orbit. Right.

EISELE Yes.

CUNNINGHAM The evaporator water control, the primary and secondary; I'll cover the secondary evaporator water control valve under the redundant component check, but they operated as advertised. The water gun I've already discussed, and the food preparation. Donn, do you have anything to add about the water gun?

EISELE No.

CUNNINGHAM One very small point, it would have been nice if we had logged the first reading on the water gun. It was not zero. It was some other strange number.

EISELE My water bookkkeeping was not kept up to date the last few days of the flight. I was drinking a lot of water.

CUNNINGHAM It's a problem. I wasn't drinking enough water the last couple of days.

6.6.3 Water-Glycol System

CUNNINGHAM The one very consistent anomaly existing in the primary glycol loop was the periodic drying out of the evaporator. It seemed to occur at random times; and when it finally did dry, it would occur rather rapidly. There is a good chance we can find this out postflight since we do have the evaporator here. The secondary evaporator did not dry out; however, it never operated longer than seven and a half hours, and I don't believe we could draw any conclusions based on that. The glycol evaporator OUT temperature primary ran between 35 and 60 degrees F throughout the flight; the only time it got down below forty and down in the thirties was on an overshoot when the evaporator would come on the line. The radiator outlet temperature on the primary loop was always maintained roughly between 30 and 50 degrees. This led me to believe that we had essentially very good radiators, with only very slight degradation, if any, during boost. The radiator isolation test, which had been extremely high priority even before flight, I felt had taken on less significance after we

took a look at the radiator performance. It seemed to really be performing very well.

EISELE I don't know how the ground feels about it, or what kind of data they got. We ran practically the whole flight without that water boiler really doing much for us. We ran into high-powered conditions for hours at a time, and about the only time we noticed was that there was a slight cyclical behavior to -

CUNNINGHAM There was a definitely more marked cycle, too.

EISELE - the temperatures. When you were on the sun side of earth, temperatures tended to go up; when you get around on the cold side, that was when they went down.

CUNNINGHAM What happens is that that is the normal cycling that goes on, but it was more marked when we had the evaporator off.

EISELE But there was a very slight difference, and it didn't make us uncomfortable, and it didn't hurt any of the quipment; we had typically nominal performance even without the water boiler going.

CUNNINGHAM Those were the times when we got towards the high end of these ranges that I just mentioned.

The radiator inlet temperature on the primary glycol loop was always between 60 and 70 degrees F, and the steam pressure worked as advertised; glycol discharge pressure was always nominal, both pumps. The accumulator quantity was a bit low; I think it probably was between about 39 and 45 percent.

EISELE It was low when we took off.

CUNNINGHAM It was at the low end of the range; it changed very little, so I never gave a thought towards refilling the accumulator at all. Primary and secondary maintained the same kind of values throughout the flight.

The most significant item is the drying out of the evaporator. I consider that an unanswered anomaly. It is something we ought to try to find out about. However, in view of the way the radiators did work, I wouldn't have any reservations about operating the system. We felt very comfortable operating it that way for 10 to 11 days. I think the time it got the highest was when it was powered up for rendezvous. An example of changing limits is after we started flying, they changed the limits.

The ground rules have always been that if the primary glycol evaporator outlet temperature exceeded 60 degrees, activate the secondary loop. They came through for the rendezvous, and I believe that they stated to let it go as high as 80 degrees. I was just a little bit surprised at that because a short time after it dried out for the first time, they had given us a new temporary limitation of 70 degrees. I guess it shows they were willing to pulse the system in order to complete the rendezvous.

EISELE — Well, they were going to pulse us, too. If that glycol had gone to 80, that cabin would have gotten pretty darn warm.

CUNNINGHAM — I think that is another very significant point, Donn - they were willing to pulse the electronics a little higher, but you get very quickly into the range of where the electronics is not the key item. If the crew gets pretty doggone warm and the glycol evaporator outlet temperatures get up above 50 to 55, it just is not taking the cooling out. A lot of the subjective feelings of heat that we had on the sunny side, Donn, was whenever we were in the attitude HOLD mode

because as you came up, you had the sun coming right in the window; when that happened you were hot. The suit loop temperature and the cabin temperature varied between 47 and 65 for a suit temperature, 60 to 75 for the cabin temperature nominally, and I couldn't really correlate that with comfort. Sometimes I felt uncomfortable when it was down at the low end of that range, sometimes at the high end of the range, and the closest correlation that I could ever make would be whether we had sun coming in the windows or not. As a matter of fact, I found the suit and cabin temperatures to be not very useful. They were long thermal constants, and they didn't really seem to mean a lot. If we saw the temperature up high and we were uncomfortable, we might throw a couple of clicks on the cyclic accumulator or something, but I never had the feeling that I was getting a lot of intelligence out of the two meters.

CUNNINGHAM Cabin temperature control was never touched from lift-off to landing. It was set at max cold manually, and as far as I am concerned, the

temperatures on board the spacecraft were quite tolerable and normally quite comfortable.

EISELE Yes, it was a good environment.

CUNNINGHAM We felt like the humidity did fluctuate back and forth; it was a function of location in the cabin. That might have been why Donn bugged out of the sack that he and I were sharing after about 6 days and slept over in Wally's sack. The primary glycol pump, no comment. The primary evaporator back pressure valves were probably working normally. I have to confess that I was a bit surprised that it took such a long time to close them sometimes. It took a long time to see a steam pressure react to closing of the back pressure valves. The instructions when you are turning down the primary evaporator are to hold the back pressure valve to INCREASE for a minute. I must confess that at times I held it for as long as 2 minutes, and there was quite often a long delay from the time I started operating it before I saw any increase in the steam pressure. When I say a long delay, I mean like a minute and 15 seconds or more sometimes. I can't be sure, but they may have operating slower than we expected.

The primary glycol evap temperature inlet valve in the ECS postinsertion checklist was placed to AUTO and never taken out of there except for the radiator isolation test. The glycol reservoir outlet valve, inlet valve, and bypass valve were reconfigured in the postinsertion checklist prior to flowing the radiators, and the reservoir was never placed on the line afterward.

The glycol-to-radiator primary valve - the radiators went to FLOW probably about 15 minutes after insertion when we got around to it on the checklist. We did not have to return to BYPASS. The radiator outlet temperature was lower than the inlet temperature after 3 or 4 minutes of flowing, and it was obvious right away that it was coming down. The only other time that that valve was actuated was for the secondary coolant test, and it went to BYPASS again prior to SEP.

Primary glycol accumulator shutoff valve - no comment.

ECS radiators, the flow control switch - we had several anomalies early in the flight, and I think it was about twice in the first 48 hours the radiator flow control switched to number 2.

It was reset and put back in AUTO, and it operated normally after that. I have to backtrack just a second to the primary glycol evaporator; I did mention that it dried out on several occasions, numerous occasions during the flight. The glycol evaporator after drying out, in all cases, was reserviced, sometimes immediately afterwards, sometimes after waiting for some 15 or 20 minutes; something like that. When it was placed back on the line, we followed a procedure as passed up from the ground, and it worked beautifully until all of a sudden it would just dry out. The explanation was given that under low cyclic heat loads, the water control valve was not doing the job it was supposed to. It was not filling enough water to match the boiling rate of low cyclic loads. The last time that it dried out, and probably the reason it was the last time, was because of my servicing procedure. In reservicing it, we were supposed to put 2 minutes of water flow into it, and during that procedure, we ended up with two different distractions associated with updating the map. I would say that we

had a good 3 and one-half to 4 minutes of water. I kind of doubt whether that would have incapacitated the evaporator, but at that time I had already decided I'd just as soon not put the primary evaporator back on the line for deorbit. The reason being at that time - but I was a bit concerned that with the excess water in the evaporator that when we did start boiling and open the back pressure valve we could have possible water carryover into the steam duct. Since the steam duct is the only one we have for both the primary and secondary evaporator, I just didn't want to take a chance on freezing the steam duct for reentry. I think the risk was probably low, but it was not out of the question for it to happen, and we did not need the primary evaporator. So that was a procedural goof on my part.

EISELE The point is that thing is supposed to operate automatically, and it failed to do so. So it was in a failure mode to begin with. I don't consider it procedural goofs in the nature of leaving a valve on too long or not long enough.

CUNNINGHAM — There are so many things going on at the same time it is a real challenge to your concentration to get one task done.

EISELE — Well, I think in general we ended up with a great number of manual tasks that should have been automatic, either on account of inflight malfunctions or because of inadequate design. It wouldn't have been unreasonable when this servicing was going on to have the oxygen tank 2 fan, for example, to go to ON for 3 minutes, so you ended up with a couple of time sequences operating concurrently, and it became a problem. Or you might be looking for a certain target over the ground at a certain time. We would like to see the ground assisting us on these things.

CUNNINGHAM — Flow control switch seemed to work fine after the early part of the flight, and it was a repeat of the same kind of problem that we had on 2TV-1 run, and I believe possibly some of the chamber runs here. The manual selector switch was utilized once for the radiator isolation test and it worked fine.

Suit heat exchanger secondary valve - the suit

heat exchanger was on the secondary loop, and we actually got cooling whenever we flowed the secondary loop. And specifically, for reentry, we activated the secondary loop, did not do a cold soak, but did put the suit heat exchanger on the secondary loop and took it off of the primary loop.

Secondary glycol pump and accumulator - no comment. Glycol radiator secondary valve was turned on for the first redundant component check and never after that.

Primary glycol evaporator control. I felt like the control was adequate with the possible exception of the comment I made on closing the back pressure valve. It seemed to take a little longer than I expected.

Secondary glycol evaporator control worked fine, absolutely beautiful system for the length of time we ran it. We might comment on the procedures that was passed up early in the flight, prior to doing the secondary coolant loop test. It was a way to reservice the secondary water evaporator in the event it should dry out as the primary did. This procedure involved putting

the evaporator water control secondary valve to AUTO where it was already going to EVAP for 5 seconds, then to RESET for 10 seconds, and repeat that step for 40 cycles. In the event that we had had a secondary evaporator dry up, it's nice to have a procedure to reservice it. However, I do not know to what degree this procedure had been checked out prior to being passed up. I do know that the last 3 years prior to flight, I had been told consistently and regularly whenever I had queried North American systems people on the question that we could not reservice the secondary evaporator in flight. That was one of the big reasons we ran a redundant evaporator check every 24 hours to make sure it was serviced. I copied the procedure down, and naturally we would have used it had we had to. Because of someone being able to dream up the procedure in 3 or 4 days, whereas in 3 years it had not been worked out before, this brought up the comment about a "Mickey Mouse" procedure.

6.6.4 Suit Circuit

CUNNINGHAM — Direct O_2 valve, apparently was not difficult to adjust to the flow that we needed; we had no trouble on the pad with it, did we?

SCHIRRA — No. It was like a signature type of valve. It is unique. John Young always had trouble with it. I just haven't touched on that particular valve, I guess. It infuriates John.

CUNNINGHAM — Okay, so the direct O_2 valve worked as advertised.

Suit flow valve - they were either in suit full flow, or after we took the suits off, they were in cabin flow throughout the flight. Cabin air return valve, the handle appeared to me to operate stiffly. I hadn't operated it too many times earlier. Did you feel like it was stiffer, or is it standard 101 suit return air valve?

We might comment that it did accumulate an awful lot of lint, et cetera, on the screens, and we cleaned them off with tape from time to time.

EISELE — We did have to go around periodically and clean off that filter and also the ones on the suit hoses. It seemed like about every 8 to 12 hours, they were due for a cleaning. They

were clogged, and it made a very effective vacuum cleaning system.

CUNNINGHAM — I think we might stress trying to set up a procedure to do that regularly, more than once per 24 hours anyhow.

EISELE — I always did the suit plugs on my watch and occasionally tried to do the suit return valve if I could get to it without bothering Wally. They got cleaned at least twice a day, and they should be cleaned twice a day.

CUNNINGHAM — For planning purposes, you should plan ahead on cleaning the suit return air valve. One of the sleep stations is under there, and you have to open panel 382, and that interferes with the sleeping crewman.

Oxygen demand regulator - apparently worked fine throughout.

Suit compressors - no comment.

CO_2 canisters - I believe we will have to elaborate here. There were no problems in operating the CO_2 canisters. At about 60 percent through the flight, in changing one of the canisters, the LMP pulled the banana plug loose from the shorting plug.

EISELE — The shorting plug broke, and we did it manually just by hanging on to the structure. We had no discharge at all at any time.

CUNNINGHAM — From that time on, we made sure that we kept contact between the side of the container and the cartridge whenever we pulled it out. Changing the lithium hydroxide canister was very easy. We should make special note of the fact that stowage onboard spacecraft 101 was two lithium hydroxide canisters shy of what was required for a 10.8 day or 11 day flight.

EISELE — We were able to stretch what we had, fortunately, into the 11 days, which led us to the conclusion that probably you could make 30-hour cans out of those that you really wanted.

CUNNINGHAM — In all of our canister changes, the CO_2 partial pressure was never above about .8 mm of mercury. At any rate, when we were faced with the problem of extending the life of the canisters, it was absolutely no problem. We extended one canister out to 5 mm of mercury down at the end, and I don't have that time here right now, but I believe that canister probably went at least 35 to 36 hours.

EISELE Pretty close to it.

CUNNINGHAM I would say we ought to enter into it if we want to try and save some good weight on the spacecraft. We ought to try to qualify these canisters for 30 hours. I felt like all of our canisters subjectively would go 30 hours with no strain at all.

Suit heat exchanger - no problem.

Water accumulators? They worked; I believe they worked as advertised throughout. If they ever missed a stroke I'm not sure that we would have detected it. I believe the ground asked one time about missing strokes. We happened to be at manual as a time stroke came up, and we were trying to operate with some manual cycling. If we felt like the humidity was getting a little bit high, or we saw water in the suit hoses, we did throw a couple manual strokes on the cyclic accumulators. Something which had never dawned on me in 3 or 4 years of operating this system was that cyclic accumulators stroke right at even 10 minutes. We always knew it was 10 minutes between strokes, and 10 seconds for a stroke, and if you want to watch to see that the

cyclic accumulator is working, you can look at an even 10 minutes, on the GET. Like 50 minutes past the hour, on the hour, 10 minutes past the hour. I don't know if that's ever been called to anybody's attention before, but it made it a lot easier checking these things for operation. Okay, I think what I would like to do here before I go to the gaging system is note the differences in the redundant component check in the ECS system from the checklist. We never did read it down to the ground, and I don't believe they are aware of the changes that we did make. Okay, starting with the standard checklist ECS redundant component check, the procedure was modified in flight as follows. The first change went along with an agreement with the ground that we would only flow the secondary radiators the first time, check the temperature sensors. And the secondary radiators were isolated for the remainder of the flight. The urine dump heater, switching to redundant heater was never done. We felt that as long as we were on a good heater we were not going to change it. Evaporator water control

secondary valve was not turned off after the redundant component check. It was in AUTO throughout the flight after we pulled the first ECS redundant component check. This was because the primary evaporator was acting up, and we wanted to be able to initiate secondary evaporators should we need it. You know, without climbing under the couch, and opening up panel 382. I think the significant point here is we operated for 11 days with the valve in AUTO, and prior to the flight North American had some reservations about the AUTO position being susceptible to leaks in this loop. I personally would recommend leaving it in AUTO, and that saves you one trip into and out of panel 382 a day. If somebody is sleeping down there it complicates things. In performing the secondary coolant loop activation for redundant component check, I neglected all of those steps associated with shutting down the primary coolant loop. I always felt the secondary coolant loop with a radiator bypass and the primary coolant loop was doing its normal job.

6.6.5 Gaging System

CUNNINGHAM — Temperature gages - I read earlier what the range of the temperature gages was in both the suit and the cabin temp. I felt that it did very little good to tell you really what the comfort level was in the cabin. Sometimes when we felt very hot the cabin temperature gage was reading down in its low end of the operating range, and sometimes when we felt fine it was up toward the high end. Pressure meters, fine. Quantity meters on all consumables associated with the ECS system were GO. Flow rate, I can only stress again how important we thought the oxygen flow rate meter was. That's not listed as a mandatory piece of instrumentation for launch. Personally, I would like to think that that should be mandatory for flight, the O_2 flow rate meter.

6.6.6 Waste Management System

CUNNINGHAM — The waste storage vent valve. I utilized the valve on about two occasions for opening up the waste storage compartment. However, I never had the feeling that this was necessary. I

don't believe we ever got odors out of that waste storage box.

EISELE No, we didn't.

CUNNINGHAM Did you Wally?

SCHIRRA No.

CUNNINGHAM We opened it many times and saw little tiny bits of metal.

SCHIRRA I told doc I didn't like all the pills wrapped in metal foil because they start floating around the cabin.

6.6.6 Waste Management System

SCHIRRA — While we are talking about waste management, we had a lot more room in the command module to work on waste management; therefore, it wasn't a total nightmare, but it was a fantastic work load compared to other things. It took a long part of the day, and you had to plan way ahead for it.

EISELE — I thought it took about an hour - the whole deal - from preparation until you were completely through with it.

CUNNINGHAM — I wrote up a little thing about it that I would like to just put out as a memo to our guys in our office on it. I said to allow at least 45 minutes. I think everybody agrees, at least 45 minutes.

SCHIRRA — I think the significant thing is that whatever procedure we use, we are not prepared to handle what I would call a fluid bowel movement. That is where we were very ... lucky. I was deathly afraid of that.

CUNNINGHAM — I think that is an emergency situation when you are faced with it, and I'll say that you probably

are getting down to a two-man operation if you have that right now.

SCHIRRA — Let me make a point here. I asked Chuck Berry if we could possibly sit down with the appropriate engineers and doctors and say all the dirty words, and get it out of our system, and all the funny jokes, and then sit down and talk about this very seriously. I asked this of Stan White back at Langley, and no one has ever moved. I asked it of Dick Johnston, and I think it is kind of gross to go all the way back to the Gemini glove thing, which will suffice for the lunar mission.

CUNNINGHAM — I think I have an idea that I could add to a new kind of fecal cannister. All of these require flow rates, incidently.

SCHIRRA — For AAP, there is no way that you can go along with a system like this.

CUNNINGHAM — If you want to make a note of it, I do have certain ideas that I think could possibly end up working with a modified type fecal cannister, as long as you have flow rate. I guess what I am saying is that you know how concerned I was before we flew, running around here begging

everybody to take a bowel movement. I guess because the stools were relatively firm, it turned out that we didn't have any real bad problems.

SCHIRRA It was just a mess.

CUNNINGHAM That's right; it was a mess.

SCHIRRA It really means you have to be off the loop completely; you have to take your communications away; you can't do anything. You are strictly off the line for about an hour.

EISELE I did mine on the night watch while you guys were asleep so that I wouldn't disturb you, and I had the whole cabin to myself. What I would do was wait until I had a pass where I was going to be 45 minutes to an hour between stations - and usually during my watch there would be a least one pass like that. That's when I would do it because you have to take everything off, strip right down to do it.

SCHIRRA Donn, it just occurred to me while you were talking that you are not going to have that on the lunar flight. You are in constant communications. There is always some message coming in.

You just have to say, "The CMP is going to be off the line for 1 hour." The way we did it was idealized for the environment that we had, but I guess in this debriefing we've also got to project ourselves to the next one. I didn't dwell very much on the S-IB because it's history as far as I am concerned, other than for the AAP. I think we should go into the AAP debriefing as I discussed with Deke.

EISELE The whole procedure is not all from an esthetic point of view, it is not as bad as I thought it would be, frankly. It is tedious and time consuming, but if you take your time, you can do it right.

CUNNINGHAM I'd rather not go into all the details right here. I did spend a lot of time writing down stuff that I'd just as soon pass on to the guys that are going to be needing it and to Berry. In fact, Berry made a copy of what I wrote down about doing it. If we are talking systems-wise, we still have the operational problem of the interface between the man and the bag, et cetera. Systems-wise, things worked as they were expected to before we went in flight, on the waste

management and fecal waste. On the urine system, I would have bet money before we flew that we would have freeze-ups. We were all absolutely amazed that the water dump system worked so perfectly.

SCHIRRA We were very religious about prepping it.

CUNNINGHAM That's right, and purging it afterwards.

SCHIRRA We overpurged it most of the time.

CUNNINGHAM I think we have already belabored the point of the dumps and the stars and the fire flies and the snowflakes. Have we really made it a point that this could be a critical problem in later moon flights? I don't know. This is one of Wally's little pet points, and I think he ought to elaborate on it a little bit.

SCHIRRA My point is that in earth orbit the W/CDA of the particles is quite different in the spacecraft. As a result, it draws aft and separates from it. Eventually, you fly out of it.

CUNNINGHAM You also go from a sunrise or a sunset situation, into a total darkness or a total light which changes it.

SCHIRRA In sunrise or sunset, when I tried to do my coarse alignment, I could not find star 1 for

10 minutes after sunset. I was all set for it; I know where they were. I had already seen the stars at dusk before. It wasn't a case of really trying to find them. I just couldn't see them. If the particles don't draw away from the spacecraft enroute to the moon, we'd have a real nightmare. That is why I say that we should keep the platform up until we discern whether there is a problem or not. That is the only real frightening thing I saw in this mission. It really did scare me for a lunar mission, even more than seeing stars in daylight.

SLAYTON That is the plan on C', to leave the platform on.

SCHIRRA Then we will find out whether these do in fact draw away or not. They leave the spacecraft with enough velocity that they might go away just by that DELTA-V that is applied through the nozzle. There is a fantastic cloud of these things that go in all different directions. It is not just coming out that spray nozzle.

CUNNINGHAM I brought up a point in flight that at first blush sounds just a little bit ridiculous maybe; I think he thought I was being facetious, but I did mean it half in seriousness. If you had a

directable urine dump, you would have a means of controlling that spacecraft, except at perigee or something. Every time we dumped, we put torques on it, and if you could direct a nozzle out there, you could fly around for -

SCHIRRA I didn't think it was facetious. I saw as much as two tenths of a degree per second.

CUNNINGHAM I thought you might have been thinking I was making it all in jest, but I wasn't. I think if you had a directable urine nozzle or a waste water dump nozzle, you could fly around in earth orbit, take pictures - a poor man's control system.

SCHIRRA It is not appropriate for Apollo, obviously.

CUNNINGHAM If you could get all the vent stuff coming out of one hole maybe, then with a directable vane - turn around one way or another, you could do something with it.

SCHIRRA Donn, do you remember what the peak thrust of a pulse is? It's not very far, not any hundred pounds.

EISELE No, the effective ISP is about one-half or a third the normal - pretty low.

SCHIRRA I know on Mercury I wanted less than a 1 pound thruster, for example. We didn't have pulses as such, but we used a small thruster. They were great. I'd say that in Mercury, we got about two tenths of a degree per second for a minimum fly-by-wire thrust in a 1-pound thruster. I bet you get more than that out of these overboard dumps. Although the acceleration is not there, you are getting the rate by letting it build up over a period of possibly a minute.

EISELE If you dump water out of that waste tank, it really spins it up. You get a good healthy rate out of it.

SCHIRRA While we are talking about dumping water. We actually saw the shadow of the spacecraft in these water particles.

CUNNINGHAM Whenever the spacecraft was trailing the urine dump in orbit, it made a nice shadow back there. In fact, Wally and Donn saw the -

SCHIRRA We saw the whole spacecraft; saw the engine, everything, the command module, the service module -

EISELE And at one point, we were silhouetted against it.

CUNNINGHAM It suffices to say that I wrote up the checklist we used for it, which is a significant number of steps, and I would just as soon leave the thing about waste management to a little memo. Another point to mention here that we didn't mention is the odor. The odor did hang during -

SCHIRRA Yes, I don't know what we could do to solve that.

CUNNINGHAM The only thing we could do, we did.

EISELE We breathed out of the blue hose.

SCHIRRA That was better than going to the mask. I guess that is an appropriate comment to make, expecially towards the end of the mission when it began to definitely - we were clamping up our noses. We also noticed that our body odor was up. I understood from Frank Borman and Jim Lovell that they didn't feel that dirty. They didn't get the exercise we did, either. Even though we didn't break into a sweat or perspire while exercising, I suspect our wastes were coming out through our skin more so than -

CUNNINGHAM One thing about this is that the waste management overboard drain valve got a lot of work. Sometimes I had the feeling that we were about to break all of the waste management valves.

The waste management valves are not a nice operating valve. They go only one way. It looks like you can go either way because it's a 180 valve for VENT or CLOSE. After 5 or 6 days, you always turn it the right direction first. There should be an arrow on those valves showing the way that they move.

SCHIRRA Walt, that is a good point that you are bringing up. Second, there are so many of these tool E valves - I hope the world doesn't follow that as a normal pattern for identification for what way a valve is pointed. It is a hex hole that tool E goes in. There's a lip of a guard, I guess, and you are not sure until you live in it for a few days which end is pointing in the right direction. It is a very bad standard to be used for subsequent vehicles is what I am trying to get across here - to identify where a valve is pointed. We learned, incidentally, each time we looked at them.

CUNNINGHAM I have one more thing to add along the same lines; it is sharp in my mind now. The stowage box RL3 has some handy-dandy handles on those ratchet things you fasten. If we could stick

one of those on one lithium hydroxide fastener, (the cannister cover) and one of them on panel 382 fastener, we'd have a whole bunch of tool E valves -

EISELE You can't because those have to be flush.

SCHIRRA You can't, Walt.

CUNNINGHAM The lithium hydroxide cannisters? What I am getting at is that we opened it, we hooked it back with tool E to fasten one or two of them, and every time we wanted to get down there to clean the screen or anything else, we had to go get a tool E and come down to do it. If we just had one of those -

SCHIRRA Let me ask this. Didn't we find that that wasn't a very highly reliable thing?

CUNNINGHAM Never had any failures with the ones on board.

SCHIRRA Yes, I know, but each one of those is a potential failure.

CUNNINGHAM There may be mitigating circumstances which won't handle it, but my feeling right now is that is sure would be handy.

SCHIRRA I think it really is a nuisance to go around and undo those things with tool E all the time. What was that tool stowage thing for down there that we didn't have a tool for? Was that tool E,

another version of it? On the water control panel, there is a hole that say tool stowage.

CUNNINGHAM — Oh, we used to have a tool stuck there.

EISELE — There used to be a tool that would stick in there.

CUNNINGHAM — That was its standard position.

EISELE — There is an extension in the tool kit that you can put on tool E, and it would probably fit in that hole.

SCHIRRA — It came back as a T-shaped tool that went up where my direct O_2 knob is now, and that same T-shaped tool -

EISELE — It would be handy for exactly the best purposes.

CUNNINGHAM — I really think that if there is a way of throwing it on, it is a convenience type thing.

Dew-Point Hygrometer

SCHIRRA — The point is we took twelve different dew-point hygrometer readings, which is almost on a daily basis, and there is a lot of good data here. We found out where the moisture was. That's really what we were doing it for, in case there was any. The moisture collects on the coldest place on the spacecraft.

EISELE Which is down under your seat where the cold pipes are.

SCHIRRA From that, I see no reason to carry this device along. It's not an operational instrument any more than the cabin gas analyzer. We have all the data. This data has been sent in, here is a whole page of it right here. This should be sufficient to dispense with the hygrometer. We were using the suit return air valve, and we dropped that and went to inner condensate which collected on the pipes. In one case, we measured the pipe temperature, which was 52, and the wet bulb was 58. It had to condense; that's all there was to it. Whatever the spread was, the dew-point was higher than the pipe temperature, so the water had to go there. Oddly enough, back in block I days, we saw this very often. Remember they had the air conditioning fouled up in that big vertical bay building in the plant? People came roaring in and started wiping pipes off because they wern't insulated. They reset the air conditioners somehow or another to lower the humidity. I've been told that 106,

and possibly all on up, are insulated, and on a phone call to Kenny I suggested that he insulate what he can.

6.7 Telecommunications

6.7.1 Monitoring

SCHIRRA I think the surgeons went about as far as they could to help us on the BIOMED switching (the three-position switch). It was a gross mistake on their part for not insisting on having the ground control it like anything else. It ended up as a crew task because they didn't win their fight. They did win it for later spacecraft. We were not unduly exercised on that -

EISELE Once every 8 hours.

SCHIRRA If you will recall, the original flight plan was absolutely unreal. We couldn't have abided by that; there was no way we could have. I gather they got the data they needed out of it, and unfortunately, we are in a problem. As far as I am concerned, the BIOMED harness is an open anomaly for this mission for two reasons. One, it failed; and I told Chuck Berry it's possible that Donn's failed as mine did as a result of exercising against the seat belt. Mine failed because the lead was just too short; they put the bio-sensor in the wrong place. Changing configuration between where they placed the

sensor between the last time I wore it and flight day, caused it to come apart. I taped it to make it stay together, and it broke down the next day.

EISELE I guess we have already documented the hot signal conditioner elsewhere. That happened about 7 days into the flight.

SCHIRRA I would like for you to get it on this thing. You told the doctors. How hot was it? Berry was telling me it runs about 98 to 100, which is not enough to detect.

EISELE No, that's body temperature; you could hardly notice that. This was plenty warm, and it had been getting warmer over a period of a day or two. I could recollect that now and then I felt a little warm in my abdomen; and one day, it was quite warm, uncomfortably so, and that is when I started searching around to see what the problem was. It was one little single conditioner, so I was just going to take it out, and I thought, "That is the power supply for the whole thing, and I will just - "

SCHIRRA The black one?

EISELE No, it was the red one. I took it off and advised the ground, and they said, "Roger."

SCHIRRA That shook me when I heard it.

EISELE It wasn't hot enough to burn you, and it wasn't so hot that you couldn't hold it in your hand, but the fact is that there was a short in it, and it appeared to be getting worse over a period of a day or so.

SCHIRRA To help you calibrate a temperature number, the water was about 150, and that was kind of hot.

EISELE It is kind of hard to compare because of the heat transfer rates of different materials involved. I would say that it was probably 120 to 140 degrees by then, something like that. It was quite hot to the touch.

SCHIRRA You're not supposed to get that kind of flow through there; something is wrong.

EISELE Yes. It sure was.

SCHIRRA Destroys my confidence in that report we had about triggers in the suit loop.

EISELE I was concerned if I got a hot short in there that it might singe the cotton garment I was wearing and would have been -

SLAYTON Theoretically, there is no possible way to get that much current in there, but it is an unknown thing that has to be explained.

EISELE We took special care of the equipment. I don't know if they ever found it, but it was in the remaining fecal bag box, the box that the fecal bags were stored in.

6.7.1 Telecommunications Monitoring

CUNNINGHAM — I am assuming this means the status of Telecommunications System. We launched as nominally planned on all switch configurations, etc. Did you cover the COMM problem? Apparently, Duplex B wasn't working all the way through boost. I didn't notice a loss of COMM. I was monitoring meters instead of waiting for some of the calls. Apparently, there is an anomaly, a loss of COMM. Did you hear all the calls here at the Cape? Didn't you have a COMM loss here at the Cape?

SLAYTON — Redstone was down. We didn't hear them after the boost.

CUNNINGHAM — In monitoring the S-band antenna meter, we never lost S-band lock. It seems that we should have had S-band COMM. Wally said, that he did turn the S-band COMM up. I can't really account for not hearing one or the other. This is the first I had heard about it, and I am very surprised. Throughout the flight, the COMM operated just as you would have expected it to operate. Sometime in the first day, they lost the PCM, the real time PCM was down.

The man on the console somehow or other (in looking through the malfunction procedures) skipped the first step, which is switch transponders, and went to the second step, which is switch the PMP to auxillary. The next morning when the day shift came on, they switched transponders, and everything was back to normal. We used the primary transponder, secondary power amplifier, on high throughout the flight from then on. I would like to comment that the S-band loss of lock problem in selecting the right antenna was definitely a pain and took a lot of time, but it was not as bad as we had expected before flight. The S-band power amplifier on high worked pretty good. We never Rogered transmission on antenna switching; we just went ahead and switched. We did not always wait for the ground to call for switching: at least I didn't. If I looked and the antenna meter was dropping down around where the down lock would have dropped out, I would switch to the opposite antenna. On rare occasions, they called for an antenna which was in-between the two that we had gone on. For

all known fixed attitude maneuvers, I used the pre-programmed flight plan callout for an omni antenna. We going to cover the DSE in separate categories. We did have a problem with the DSE.

6.7.2 Audio Center Controls

EISELE — Walt was complaining that his S-band thumbwheel was a little stiff, but he said later on that it loosened up. I didn't have any trouble with mine.

SCHIRRA — When I used Walt's, I didn't notice; I guess the S-band was a little stiff.

EISELE — One thing I noticed on mine was that after some length of time, it would go so that I could reach up there and manipulate it in the blind. I could do it by feel; I knew which switch and thumbwheel was which, and I knew which way to push on them. It wasn't as inconvenient as it was at first when I used to have to get out of the couch and go up and actually look at what I was doing. Also, on entry, strapped in without

the helmet and gloves on, I found it was possible to reach up there and actually get a hold of that S-band volume knob.

REP Oh, could you?

EISELE Yes, sir. I don't know why I could do it on entry and not on launch. Maybe you don't get strapped in quite as tight; I don't know.

SCHIRRA Let me ask you this, Donn, because some of the crews have a different way of wiring the launches. We discussed it and rejected it, I guess. It was for you to launch in backup so you would be over on my audio control.

EISELE We talked about it, and I thought it was a pretty good idea, but it was kind of late in the game when it came up. We hand't run any test or training on it, so I felt we should leave it the way it was. I recommend they try it out.

CUNNINGHAM It sure sounds like a good bet to me.

SCHIRRA It bugged me, and I was a little afraid to try it because by DB went down about 2 or 3 DB's when you came on my side.

EISELE Little things like that could eat you up if you do it the first time on launch day or something.

CUNNINGHAM Yes.

REP But now do you feel you are missing anything? You obviously couldn't get S-band.

EISELE No, but you two guys had it.

SCHIRRA I might add that I finally ended up with my S-band at about position 2. I could hear the guy, but he was so weak I couldn't -

EISELE That's another point. During the flight I found that by putting that S-band volume at around one and a half or 2, you could just barely hear the grass when it is not locked on. It is a very good key to the fact that you are coming up on a station when you hear that grass disappear because you know somebody is getting ready to talk to you, and it was very effective.

SCHIRRA It was quite significant, that, and that sensitivity meter, I guess is the word for it, the S-band lockup -

CUMMINGHAM It must have been a lock. There were times when I was somewhere and not looking at that meter, particularly on the night watch when I was up there by myself, or when I was down in the LEB. I heard that noise disappear, and I figured we were coming over a station.

CUNNINGHAM — A comment was made about my S-band thumbwheel being tight. It had always been tight preflight, and by about the eight day, it was finally loose enough to where you could turn it without great strain.

6.7.3 VHF

CUNNINGHAM — I operated almost completely throughout the flight on VHF antenna left. A couple of times when I wondered why they weren't receiving us on VHF, I did switch to antenna right. I could find no difference in our COMM regardless of which VHF antenna I was on. I drew a kind of tentative conclusion that it was fairly insensitive to which VHF antenna I used, which was kind of a surprise. Squelches were left sitting at launch squelch values. I manipulated one of them once and set it right back to about five and a half. That was where we launched.

EISELE — Squelch control. We didn't use it at all to speak of. We launched apparently in the wrong mode. I'll say that because it didn't work very well. Check the recovery beacon. It worked fine once we got in stable 1, didn't it?

SCHIRRA — Yes.

The ground has more data on the VHF AM COMM Mode from all the COMM checks. To my knowledge, they all worked out fine. The only possible problem with VHF was during boost, and I would have to have Wally elaborate on that. He apparently lost COMM with the ground, and they lost part of the time.

SCHIRRA We went through that.

CUNNINGHAM All the other COMM modes operated as prescribed. There was some anomalous problem in the VHF recovery beacon in that they did not receive the SARAH beacon until just prior to splashdown, although it had been turned on at someplace around 8500 or 9000 feet. A possible antenna deployment problem is the best I can make out of it after talking with the recovery people.

EISELE I noticed that fairly early in the flight. I don't recall the exact time of the floodlights, but they are noted in the crew log. That is the only lighting failure we had, and those do not really pose a problem because we still had one element in each of the two floodlights in the LEB, and the optic switches you run pretty much by feel anyway because normally you have got your eye glued to the scope. At least, that is the way I ended up doing most of it.

SCHIRRA What concerns me, Donn, is on the LEB floodlights. You recall on the strut between you and Walt, that light failed during CCDT, and it was replaced with a brand new one and very little light there?

EISELE That's right.

SCHIRRA And yet it failed again. So we are seeing what we had seen in block I. The life of these things is not necessarily predictable.

EISELE That's a good point. The floodlights just aren't all that reliable, but it's just that, fortunately, we have a large number of them in there, and each fixture has two elements in it. I do think that during spacecraft testing every

SCHIRRA Do you recall early in the mission when you were down in the LEB swearing and in complete shock about getting alignment? You were perfectly willing to do two or three alignments in one night pass at the end. I'll say this: don't take away the equivalent of two night passes for anybody to do his early alignment. To even bear you out on that, we needed it, for the rev check.

EISELE How many days into the flight were you doing this? It was your first and only time to do a 53 and 54. The first time we had a urine dump, it took up 10 minutes. It was before -

CUNNINGHAM Something there. You told us - and the water boiler suddenly decided to kick in.

EISELE Wally did a P53; he did a P54; I was supposed to do some P52 alignments. I did three P52 alignments, and it was getting light. I think that's probably about as busy as we ever moved through a night.

SCHIRRA You really get up-tightness on this thing because you want it to work right. The COAS alignment was a very difficult task, and I would like to remind Donn how difficult he thought that SCS alignment was, yet they turned out to be beautiful.

EISELE — But we thought we were busting ourselves apart to do them.

SCHIRRA — They're better than any Mercury or Gemini alignment ever was the whole time, less than a quarter of a degree.

EISELE — We came away with the thought that they had no qualms at all about using either one of those backup alignment techniques. You could get plenty good; you can get within a quarter of a degree with either one of them.

6.7.6 S-band

CUNNINGHAM — S-band TV operated normally. Tape position, no comment. Ranging, only one comment. On the down voice backup mode, I noticed that they left the ranging switch on during the test, and it apparently worked fine. I've always been under the impression that the two are mutually exclusive. If you turn the down voice backup on,

you ought to turn ranging off in order to get a better signal-to-noise ratio. It may turn out that it is insignificant in earth orbit and that for lunar distances, we would be better off turning ranging off.

Oscillator, no comment.

Power amplifier, no comment.

Transponder: we covered earlier, the secondary transponder failing. It is my understanding that had it been necessary, we could still have used the secondary transponder at least for ranging.

Emergency voice and keying all worked out just fine. I find the key to be a little awkward, but usable.

S-band up data apparently okay. Throughout the flight we never had to take a VERB 71 update. We took it twice for the landmark tracking exercises in case we had inadvertently changed our state vector. We had one to load in on board. Other than that, all up data link seemed to work fine.

Operationally, the S-band antenna selector switch is a sorry system. You have two switches,

and it should be a single rotary switch for omni A,B,C, and D. I operated probably 95 percent of the time in omni A and C. I didn't really have to move the second switch; it was selected in omni, and I moved back and forth between omni A and omni C. The antenna switching from callouts from the ground have been covered. I think we ought to leave it exactly that way. Have them make a blind call, no answer, then switch to the opposite antenna. Comparison of the USB and VHF up voice quality. What do you think, Donn? I didn't really notice a big difference, but the ground said that the S-band was much better than VHF.

EISELE — I could tell very little difference.

CUNNINGHAM — Me, too. I would say they were about the same.

EISELE — S-band might have been a little clearer, but there wasn't that much difference.

6.7.8 Power Switches

CUNNINGHAM — We did use PMP auxilliary for awhile, and apparently it worked fine.

6.7.9 Telemetry Switches

CUNNINGHAM — Telemetry switches, no problem.

6.7.10 Flight Quality Recorder

CUNNINGHAM Flight quality recorder, apparently it worked fine.

6.7.11 Voice Record Indicator

CUNNINGHAM Voice record indicator, apparently worked fine.

6.7.12 PTT Switches

CUNNINGHAM PTT switches, had no complaints.

Have any complaints, Donn?

EISELE No.

CUNNINGHAM It is a fairly large switch, but it's the smallest size you can make. After we utilized all of the different straps on the inflight coverall and the constant wear garment, I felt like it was a pretty usable system, hanging where I could get at it. It isn't a big problem. The complaint is that you have very few small wires going through there, and yet you have a great big umbilical.

6.7.13 VOX Circuitry

CUNNINGHAM We never did operate on VOX throughout the flight. We should have done that just to fill the square.

6.7.14 The USB Emergency Keying

CUNNINGHAM The USB emergency keying, no comment; it worked

fine.

6.7.15 DSE Storage

CUNNINGHAM — DSE storage is the only subject in this particular heading that I would like to expand a little bit. The data storage equipment serves two purposes, the data and the voice. I will not concern myself with the data; that's a ground problem. There are times when we are out of ground contact and high bits are required. That's where we interface with the data storage. What I am concerned about is the voice storage, the tape dump, and the fact that the tape recorder had to be rewound before it could be dumped and had to be rewound again in order to be used. Time and time again throughout the flight, we had things that we wanted to record, and the first thing that had to be asked was "do we have the tape recorder?" We got down to a procedure where if the tape motion flag was gray (meaning it was running) and we were out of touch with a station, we assumed that we could record. If we were in touch with a station-supposedly over a ground contact and it was gray, we couldn't count on

recording on it because it could just as easily have been in the rewind mode, and that's why we had tape motion. On numerous occasions - I wouldn't care to estimate how many - we left the ground site without having the tape recorder turned back to record and over to us. This is because the ground did not get the last command in to run forward in the RECORD mode, or because they took longer to dump than they had expected. Longer dump times were caused by a shorter pass than they had expected, or because we had possibly placed some high bit rate data on it. I think we ought to mention that we very seldom, ran it on high bit rate.

EISELE I remember on one occasion that I asked you to go high bit rate for some reason or another, and it tore them all up. They were really terrible, belligerent. When we got over the next station, they called up loud and clear that they sure didn't like to have that high bit rate on there in the middle of the tape. Apparently, there is some problem of switching from low to high and back again.

CUNNINGHAM That's not really the problem.

SLAYTON That is the replay; they have to do it real time as I understand it.

EISELE I understood their problem. Their high bit rate is one for one on the dump. It was only on for a minute, and I didn't understand.

CUNNINGHAM We record at 15 inches per second, and it dumps at 120 inches per second. If you have high bit rate, they want to dump it back at 15 inches per second. At the time, you said let's go high bit rate. I went to high bit rate so we could put the displays on, and now they have a problem. They now have that dumped back at 120 inches per second, and you've got aliasing on the tape.

EISELE It was during the landmarks that we did this, and on that particular pass all the DELTA-R's and DELTA-V's were zero anyway. If there is ever a question on it, we can square it away.

CUNNINGHAM The real problem that we face here is that the ground has to have a full time man tabulating the run time that is on the tapes and how long it takes to get it rewound. In the interim of coming up with a better system, we could do what we finally did towards the tail end of

the flight. Occasionally, the ground asked us to go ahead and command reset after we left the station.

EISELE One time, I did that on my own. I wanted the tape to run; I wanted to record something. I heard about that later, too. That somehow glitched them. The message I got from those two incidents to not touch those tape switches unless you coordinate and brief with the ground ahead of time.

CUNNINGHAM You didn't mention that last incident to me. Wally kept asking about tapes and I was always reluctant. I didn't want to take the tape over if we left with it running unless they have given us COMMAND RESET. Here's what can happen. They rewound it; they play half of it back; they break lock or something and can't get the command up; or they're losing the station and they stop. If you start going then, you lose all the data that's already been -

EISELE I know they are losing data, but it seems to me that the tape up there with the voice recordings on it is just as valuable as the data. Now they have been getting systems data for hours and

hours on end.

CUNNINGHAM Nobody is arguing that point. I don't think we should even address our discussion at anything but the voice. If you had voice on there an hour before, it might have been important voice; when you get to the station, they rewind and start dumping it. You get half-way through your important transmission. All I am concerned about is the voice channel. In losing the stations, they stop it. They want to catch another station 10 minutes later. Now we start recording it; if we have taken COMMAND RESET now, we lose whatever we've recorded before.

EISELE I finally settled down to just a very simple rule. As long as it was gray and not over a station, I would assume that I could record; and if it wasn't gray, I wouldn't mess with it; I just went ahead and wrote down what I wanted to say. That seemed to be the only way, which was kind of a surprise. I had a notion that the tape was more or less at our disposal when we wanted to use it. That was not always the case.

CUNNINGHAM That's certainly true.

EISELE Other crews ought to take this into account when they are planning their details of how to record on board.

CUNNINGHAM I think that we have got to have a separate voice recorder in the spacecraft as soon as we can. We commutate it onto the regular PCM and dump it. That's the only real long-time solution. In the meantime, all we can work on is trying to get a little more cooperation between the ground and flight. Ideally, you'd like to let the ground run it completely, but there may be cases where the ground would be ahead by asking you to rewind the tape before the next site. That saves them 8 minutes.

EISELE The message that I got was that in general you should not ever do anything with that COMMAND RESET switch unless you have gone over it ahead of time with the ground. Otherwise when you come over the next station, they are assuming that the switches are still their last selected position. When they find that they are not, it takes them awhile to unscramble what you've done and set it right again.

CUNNINGHAM It isn't just for the DSE. The problem with

it is that when you hit the COMMAND RESET, you gang bar all of the commanded switches to what you had, and they may have been reconfiguring those. The COMMAND RESET function did seem to work normally. The times when they asked me to throw it and I did throw it, we apparently were in the right mode.

EISELE — Before we go into miscellaneous systems, landmark tracking was not in the DTO's listing, and I would like to record a few comments on that.

SLAYTON — Let's go back to those -

CUNNINGHAM — We're going to use that as a checklist later.

6.8 Miscellaneous Systems and GFE

6.8.1 Cabin Lighting System and Controls

EISELE — The lighting on the DELTA-V counter, the DSKY, and the mission event timer all on the main display console can be washed out by sunlight.

SCHIRRA — The first time it really became a critical event was during that burn 5, and I couldn't read the darn numbers. The point I am getting at is to make Frank Borman aware of the problem and let him go fix it with a bunch of engineers involved.

EISELE — It looks like you might be able to put some small low shades around the edge of the -

SCHIRRA — You could almost tape a piece of card over it.

EISELE — Yes, that would work pretty good; it would keep the direct sunlight from hitting it. It seemed to be just because of the very bright sunlight impinging directly on the surface. It is not the total background light that causes the problem.

SCHIRRA — You noticed in the films how bright it was on occasion, and at other times, it was quite dark.

EISELE — We didn't use the sunshades at all either, and I guess the main reason I didn't want to use

them was because I like to see out and see the ground when we could because part of our flight was to get pictures of the ground. On a lunar mission, maybe you would not want to do that; maybe you could put the shades up and avoid the problem to some degree with perhaps shading the two side windows or something.

SCHIRRA If you are not burning, I agree the sunshade might be good for IFR. If you had a burn and went whistling off, you might want to look out for attitude reference as your last warning if you're tumbling.

EISELE I would never cover up the rendezvous windows. It's something for Frank to think about. I think the other crews should be aware of that lighting system problem.

SCHIRRA I guess I would state that I would just as soon dispose of the window shades, unless the crew envisions sleeping in the couches; then you had better have them.

EISELE Yes, for our type of mission, yes. We never did use them.

SCHIRRA Frank tells me they expect to sleep one time in the couches.

EISELE You might want to keep some of the window shades.

SCHIRRA You might want to keep the window shades. I guess you better not delete those yet, Deke. Just tell the other crews to tell us how the hell they are going to work.

EISELE We had three lighting failures, and they all took place in the lower equipment bay.

SCHIRRA I thought lighting controls were great. No problem with the controls, but, Donn, you should bring up the failures -

EISELE The floodlights behaved just like they do in the simulator. They do not really dim smoothly from minimal brightness all the way up to full bright. They are kind of spotty; and, occasionally, we got one that would flicker a little bit, but, in general, they were fine. The EL was great. The three failures we had were in the lower equipment bay, and we had one element of each of the two LEB floodlights go out at different times. We also had one patch of the EL go out on the G&N control panel, that little square that contains the optic switches.

SCHIRRA The optic switches. I couldn't read them.

6.8.1 Cabin Lighting

SCHIRRA — But you need all the aid you can get, and that's where those sunshades are appropriate for the COAS thing, and where those covers are appropriate.

CUNNINGHAM — Floodlight shading.

SCHIRRA — You really have to black out to acquire, and on occasions when Donn was in a hurry, we just had a blackout so he could acquire the stars if they were in a difficult area of the sky. We tried to help; I don't know whether it helped any at all to call stars from other windows.

EISELE — Yes, I was going to mention that. I noticed particularly during the P53 and 54 that Walt was in the LEB looking through the optics; I was over in the right seat staring at the stars; and you were in the left seat staring at them. Between the three of us, we managed to map out the celestial sphere pretty well and know which ones we had available. It wasn't a matter of not being able to recognize or see any; it's just a matter of picking ones that were close so that you didn't have to fly all over the sky looking for them.

EISELE — We got along just fine on that.

6.8.2 CLOCKS

EISELE The clocks are the next thing.

CUNNINGHAM Did you say anything at all about the clocks?

EISELE No, we haven't gotten into it. I think we did mention the lighting problem on the clocks? If you get direct sunlight on the MET and the DELTA-V counter, it will wash out even when the numerics are turned up full bright. The means ought to be taken to reduce time on those floods so that you do save them for flight.

SCHIRRA That's a very appropriate comment. Why don't you develop those because we always came in there and found integral lights on and floodlights on?

EISELE Yes, it's part of the general tendency of test crews or the people who write the test procedures to not specify that floodlights and the EL lights be turned off when they are not needed. I think there is some work to be done to reduce the time on the floods and the EL before flight. The EL seems to be very reliable, and I don't think we have a problem there, but those floods do burn out.

DSKY's have the same problem, although that's not as bad. You can always look down the LEB, and in fact, for the MET, I ended up using the one down in the LEB a good bit. I could just lean over and read it from the center couch when the MDC was blanked out with sunlight. We did have a problem with the MET on the main panel. It tended to lose time, and we had to correct it twice during the flight. Towards the end of the flight, it didn't lose any time at all. It seemed to work better the last half of the flight than it did the first half.

6.8.3 Event Timers and Controls

EISELE The event timer in the LEB was used only for rendezvous. Other than that, we didn't make any use of it at all. It seemed to be very unreliable at that time, and I never did get around to checking it out again to see if it was a one time type of malfunction or whether it was repeatable. The thing would drop numbers or jump two digits in the tens row for minutes. It was not a very reliable timer, and I ended up using my wristwatch for rendezvous rather than the event timer. The one on the main

panel acted up on one occasion late in the flight. At that point, I was very happy that I had two wristwatches on because we still weren't sure about the MET on the main panel. With the event timer acting up, we could have been insufficient timepieces. I think that carrying the fourth watch on board is a good idea, just to back up those onboard digital clocks in case they don't work. The controls on the event timer and on the MET worked just as advertised. We had no trouble thinking the event timer was the computer clock or any other reference. One thing we would've liked to have had was some sort of an alarm system, just a little kitchen timer that you could set for however many minutes you want to time some function. Did we already cover that?

6.8.3 Event Timers and Controls

CUNNINGHAM Did you mention the delta timer?

SCHIRRA Oh, the delta timer. We mentioned a DET failure on nine.

EISELE Yes, that was a one time thing, and it never failed after that.

SCHIRRA We cycled it a number of times after that, and it worked. It went up in units of 10.

CUNNINGHAM — One other thing on the DET: When Wally had to turn the oxygen fans to ON, the DET spontaneously started in the LEB.

SCHIRRA — A tip for the crews: where we had trouble keeping track of time on the MET was when I had to run my DET to keep track of the elapsed time, the mission time, which you normally don't do.

CUNNINGHAM — When it had sun on it.

SCHIRRA — I couldn't read it over there for some periods, especially during those daylight passes when we were trying to get ready for a landmark track and things like that.

EISELE — From the other seats, you can look at the one in the LEB, but from your seat, you can't. You have to get out of it to see the LEB clock.

6.8.4 Accelerometer Indicator

EISELE — The accelerometer seemed to work just the way it should all the way through. We could monitor accelerations during boost, during entry, and during SPS burns. It seemed to read fairly accurately as nearly as we could tell. It is easy to read. During the orbit part of the

mission, we had some little discs that we placed over those instruments so that they would not shine so brightly during darkened periods. There is a bright white light on the accelerometer and also on the altimeter, which is objectionable when you are trying to maintain a darkened cabin. Those little discs worked out real well, didn't they Wally?

SCHIRRA Yes, I think they should be provided for subsequent flights.

EISELE They sure helped.

SCHIRRA I would like to pursue that point. The hardest task I had in the mission as far as pulling everything together was that COAS alignment. I was really nervous, and I know you guys knew it. I was up and down Walt's back rather violently for having a urine dump right when I was looking for my stars. It was real quiet, and I was the only guy doing anything at that point. What I had to do is yell MARK, and all you had to do is punch a button because the computer was set up. All of a sudden, all I could see was 90 million sparkles out there when I was looking for a full moon, and I went

out of my gourd. I had wasted the whole rev getting set up for that thing, it was loose deadband.

CUNNINGHAM — I think it was because we were kind of up-tight about a particular objective. It's only fair to say that after they did settle out we did do a 53 or 54 and three P52's all in one night pass.

SCHIRRA — So it was amazing how highly confident we were at that point, but we didn't know it.

6.8.5 Electrical Cables and Adapters

SCHIRRA — I was very concerned about cables, wires, hoses, and things like that. I guess in a shirt-sleeve environment it's not so bad, because you have the hoses stowed, and all you have to do is lug the cobra cable along with you. That did bug me a lot with my short one, I'll have to admit, because then I had to keep straightening it out.

EISELE — Yes, after a while you learn which way to turn so you won't get wrapped up in it. You learn how to rig it up when you first put it on, for example, after you've been sleeping, so that you don't get tied around the other guys' COMM cables. These were very minor problems, and I

think that after the first day or two, we didn't have any trouble with out COMM cable interferring.

SCHIRRA That's a good thought, too. When we changed seats, we did change cables. That was much easier for the burns.

CUNNINGHAM For the burns, that worked out.

SCHIRRA This would be appropriate for subsequent crews when they put different people in different seats for the events we were talking about.

CUNNINGHAM I think we finally got all the connectors working right on the adapters on that spacecraft. It was a long hard fight to get it done, before lift-off. We had a nightmare with the little short ones like the power cable to the movie camera going on at the right places. We never could get the one to work down in the LEB, and it finally did and we never used it. We made note of that; never used it for lighting or anything.

EISELE That electric power cable was typical of the ones we've seen in the past. It had a failure mode in that the light that is supposed to tell you that the machine is running stayed ON when you turned it OFF; however, it turned the camera OFF almost every time.

CUNNINGHAM That's our cable, a little light in there that has a fuse block and all that good stuff.

EISELE I can't figure out why the light is there, it doesn't work right.

SCHIRRA When you turn the camera OFF, the light stays ON.

EISELE When you turn the power OFF to the cable, the light will go out, and next time you start over fresh. You recock it -

CUNNINGHAM I don't really see what that light was supposed to tell me because the camera would run and you could hear it.

EISELE I don't think it does anything, but it gives you something to think about when you're using it. It outpsyched me every time. I would try to guess when it would be ON, and it never was.

CUNNINGHAM I don't remember any failures or anomalies with any of the cables, though. They seemed to work fine: we never had to drag out a spare.

EISELE I think what I would like to make plain though is that I still would never delete those spares. It was a campaign to get them on, and I think you ought to have the spares.

SCHIRRA If you recall, we had a spare camera body that we were worried about, a movie camera body, because we didn't know about IVA. We though that was the biggest thing we had to do on this mission other than DTO's. It turned out that it wasn't a problem, but we were prepared for a camera failure. I don't think you need two movie cameras for IVA, but I do think that in lieu of what we have seen we need two Hasselblads.

EISELE It depends on what you want to get done, Deke; if it's an unknown, and you really want to get it, then you should have two in there.

CUNNINGHAM What you might go to is just the body.

REP The lens? The lens are interchangeable.

SCHIRRA Did you guys feel that we were in a spaghetti bowl?

CUNNINGHAM Never did.

SCHIRRA We thought we would be with the water gun out and all the other stuff; it really did scare me.

CUNNINGHAM There was a lot of stuff out, but it didn't seem to get in the way. There was a lot of stuff hanging loose, and it didn't always look so neat, but it wasn't in the way at all.

SCHIRRA I think our collective discipline was very good. We didn't leave things out; we put them away all the time. The only thing we were sloppy on - and it wasn't in the way - was the urine dump thing because you were using it all the time.

CUNNINGHAM The other thing is that the people cleaning up the spacecraft on the carrier couldn't believe it. They said, "Boy, this is a clean spacecraft!"

EISELE We left some things lying out that we hadn't planned on, like suits were lying there.

SCHIRRA We did very good housekeeping, and that's a requirement. We very rarely took out more than we needed. Like meals, we took out only three meals at a time. At the end, when we wanted to empty a box, we had the most.

EISELE Yes, there were two meals per man out.

CUNNINGHAM Back when we brought up the spaghetti bowl, the only real problems we had with cables interferring was actually us guys; our cables interferred with each other, crossing the cables. That's the only interference problem we had.

SCHIRRA Once in awhile, the water gun would get messed up through there, but it wasn't bad. Not enough to make a crisis. I thought it would be.

6.8.6 Crew Compartment Configuration

SCHIRRA Crew compartment configuration -

EISELE Just mentioned that, about stuff being out.

SCHIRRA I think the other thing I would like to make note of is that we were luxurious as far as volumes for stowage; gosh, it was great. If you took clothes off, you could go to the stowage locker and put them in there temporatily, and there's lots of room in there for stowage. There was in our configuration.

EISELE The Velcro patches on the wall are very useful for holding just anything, cameras, meals, pencils, anything at all that you had out. You could glue it to the wall, and it would stay there.

CUNNINGHAM We plan on trying to update the proposed Velcro usage from what we used and what we didn't use. I will say that some Velcro was terrible.

CUNNINGHAM I used it. I wouldn't make a case for deleting it. All I am saying is I certainly couldn't make a case for using it and I noticed that I went for the first 3 days without my booties on, which had the Velcro. Donn went for the last 3 or 4 days without his booties on which meant that you couldn't use the Velcro at the duty station. I thought it might be nice to have it for waste management. I stripped all the way down and all I had was my skivies around my legs I didn't have my booties on.

SCHIRRA I used it for urine dump, is what I am getting at. Donn, it seemed just floated around the LEB during urination.

CUNNINGHAM Yes, I always braced myself between the walls--

SCHIRRA Everybody has their own little habits. Now when I used it for fecal jobs, I used that strap routine to keep me in.

CUNNINGHAM Did you?

SCHIRRA Yes.

CUNNINGHAM You are the only guy I know that ever used it for anything.

SCHIRRA Yes. I couldn't get a good grip on my toes on

the struts and the strings that held the L-shaped back down.

CUNNINGHAM Okay, what I am saying is - I would, if it were me, try to talk people out of trying to add a lot of Velcro down there for foot holds.

SCHIRRA There we all concur.

CUNNINGHAM And I would never go to anything fancier.

SCHIRRA No. If you saw the films he had his feet on it. You don't need it. I did sightings from the side. So the Velcro for the G&N station is not required. As long as it is in, leave it there. It does help a little bit. Maybe one guy will like it and another may not. They don't need to have any more.

CUNNINGHAM I think it might pay to relocate some Velcro patches in the LEB. The ones to the left and the right of the guidance and control panel down there are in the way of the left and right crewmember's feet because their feet are down there moving around. If you hang something on the wall, it is apt to get kicked loose. On the other hand, there is no Velcro, in the center below the EL lighted checklist. I would suggest that on other spacecraft you take some

of that Velcro off the left and right panels where where the food lockers are and move it over to the location below the EL checklist on the gimmic panel.

SCHIRRA Don't you think it is incumbent upon us to help the guys on this subject? Physically, like help Borman with his shades for those lighted things and Velcro--

REP Yes, I think they would be happy to get any recommendations you have in that area. Those are pretty well locked in on 103 anyway right now.

SCHIRRA Like anything else Deke, you try to come back having learned something. We should be able to respond to some of this stuff.

If it will make it easier for them, let's do it.

REP If there is any thing they don't have that you think they ought to have, that is the thing to discuss. I don't think we want to go in and start tearing anything out of there.

SCHIRRA No, I agree. It's true.

CUNNINGHAM Along with it, the next flight is operated more like ours than any others will be. Bill Anders and Fred Hays were in the other day and they

said after we get through with debriefing for all the crews, they would like to sit down and talk to me about watching systems, for example. I think we ought to.---do a lot of that in the long run.

SCHIRRA Well, Walt has some comments about deleting some mirrors.

CUNNINGHAM -- stowage was kind of random. We just put things on the wall where you happened to be or where you thought you were going to need them and we made extensive use of the temporary stowage bags and of the little compartments-- F1 and F2.

Very handy for any assorted items you wanted to put in.

SCHIRRA An interesting observation; when we broke the suits down, we used those right away. Donn stored the gloves in them.

CUNNINGHAM Temporary, until we got the suits and put the gloves back on the suits and stowed the whole thing.

We were talking about Velcro. Velcro patches without many scratches around them haven't been

used very much, as far as looking at our spacecraft was concerned.

SCHIRRA — You see a lot of traffic around some Velcro patches and some just fresh as a daisy. I wrote in the spacecraft, "not used."

6.8.7 Mirrors

SCHIRRA — Mirrors, you want to talk about --

CUNNINGHAM — Yes, it's in here someplace. We ran several different items that I think all of us recommend strongly, although you will probably run into some opposition individually from follow-on crews. That lower equipment bay rotation handcontroller back is deadweight.

SCHIRRA — We are backing Dave Scott directly on that. That deal of taking both sticks down there, and we're saying IVA is so easy you don't have to do that.

CUNNINGHAM — Donn flies the thing by leaning back here and flicking the handcontroller if necessary.

SCHIRRA — Well, Donn, do you really feel if you were alone in there and you had to do a midcourse from there you could do it? Or would you have to have a translation down there? Or would you go up to the seat?

EISELE Oh, I think I would go up to the seat and do it. It's no big deal to get from the LEB to either left or right seat and it takes about 3 seconds to glide from that location.

SCHIRRA I would suggest that the other crews consider what we did before, because we were so worried about our handcontrollers and the cables. Leave the things where they are unless you have a failure. The risk of breaking one of those cables is still very high. We got kind of scared one time when they started getting caught. As a matter of fact that's the way we want to handle them though.

REP It's a valid comment, but before anything changes, I think we ought to come in with a flightcrew ops RECP with everybody having a chance to put an input in anyway.

SCHIRRA I don't want to stuff it down their throats.

REP No.

SCHIRRA The point is that no one is really as aware of that fact as we are. We are IVA experts. Donn particularly can evaluate that problem because he was on it 8 hours a day.

REP Any time we can get out stuff that we don't need, we ought to get it out.

SCHIRRA All we had to do was watch out for each other because there is a little traffic in contact with Donn. The reason the requirement is there, is the one-man rendezvous.

EISELE I had an occasion now and then during my watch to use the handcontroller, particularly when I was trying to setup for an alignment - say preparation for a burn and you might have to know rates or something. It was no problem at all just to go from the LEB back up to the left couch if I wanted to look at the displays or grab either handcontroller no matter which one and take it out. I found no need at all to mount one down in the LEB.

SCHIRRA Oh, another thing we decided. Donn was a little worried about how to see the FDAI. We used the mirror on my side, just preset it. You could get down in the LEB and look in the mirror and see the FDAI reflection.

EISELE That is a good tip for a one-man effort. Use one of those mirrors to monitor the 8-ball from the LEB.

CUNNINGHAM At any rate we mentioned the handcontroller bracket. The other thing is, there are two mirrors still left on the right hand side that were there to monitor down the X-axis of the spacecraft. They are absolutely useless for anything except looking at yourself in the morning, admiring your beard, and combing your hair.

SCHIRRA You have side mirrors for that anyway.

CUNNINGHAM I would suggest we keep the articulated mirrors, the ones with the joints you can pull out because you are going to need them if you have to get pressurized and strapped in. The other two mirrors are absolutely dead weight.

SCHIRRA I would delete them and get them out of the way. They are almost in the way. Leave the bonded structure there, and naturally the bracket, but take all the unscrewable and unboltable stuff off and junk it.

CUNNINGHAM If there is any way to get rid of the scar weight left from the fecal canister do that.

SCHIRRA That can be done. I looked at that.

RLP Stuff like that can all be done in line someplace.

SCHIRRA — You just take a screwdriver to it Deke, and take it out. It is just a case of getting inside and doing it. We almost started taking it off ourselves but it wasn't worth it.

6.8.8 COAS

SCHIRRA — On the COAS, very late in the game, maybe about 6 weeks to 2 months before flight, I asked and was granted a third COAS bulb to be in the COAS in its boost position. That is the only bulb we used. It didn't get hurt at all during boost. I think it is a good idea. You don't even have to go down below and get one. The reason I asked for this was, if I had an abort I could immediately take the COAS off that side panel and bring it up to the window and I had a good visual reference system for direct X-axis appraisal.

REP — The 103 guys asked for the same thing and I don't understand why we don't have a bulb in boost.

SCHIRRA — They said the bulb would destroy itself during boost.

EISELE — It's the only one I used. I never even used the two spares.

EISELE It's the only one I used. I never even used the two spares.

6.8.9 Clothing

SCHIRRA Okay, on the clothing I think each of us should make our remarks - Walt and I of course, --

EISELE Can I go back to COAS one time. I would like to--

SCHIRRA Well let's get that COAS boresight down officially.

EISELE Yes. As it turned out, we ended up doing two COAS boresight checks in the flight. I did the first one on the first night watch and found that it was about a degree off in both axes from what it should be for the X-axis. I have them here.

SCHIRRA Oh, you have them here?

EISELE Yes, there was - to begin with, the first one. We had a shaft angle of 359 degrees and a trunnion of 56.4 degrees, which worked out to be 1 degree off in pitch and yaw from what the true spacecraft X-axis should be. That is related to the IMU, of course, the NAV base. Later in the flight, and this was after the COAS had been removed and stowed and

reinstalled, we did another one. This was just before or during the time you were doing P53's Wally.

SCHIRRA Yes.

EISELE The shaft angle at that time was exactly the same within a couple of thousandths. Then the trunnion angle shifted by a tenth of a degree. The point is that it is very repeatable. Once you have done a decent calibration you can remove it from the mounting and put it back on and have reasonable confidence that you still have good numbers.

SCHIRRA Good point. I forgot that. The guys were asking me how repeatable was it.

EISELE It was a tenth of a degree.

SCHIRRA It is very repeatable.

EISELE We felt pretty good about that, finding out that the COAS mounting was that solid and that you didn't have to worry too much about bumping it and knocking it out of line.

SCHIRRA I think it is worthwhile noting, even though we were a degree off, in both axes, X-Y in that sense, this was not boresighted as other

spacecraft will be. We did not have a docking ring up there to boresight to.

EISELE We didn't really require boresighting. All we required was to know what the alignment was. Of course, we got that from the sextant alignment check.

SCHIRRA Did you redo these numbers in your mind, is it in the northeast quarter where the urine is? Is that right?

Maybe you ought to work on it for a while.

EISELE Yes, I could work it out again. I psyched out the same quadrant. I don't remember what the numbers were, but I psyched out the same thing.

SCHIRRA What I mean by the northeast quadrant is that-- the target on the boresight, that is the COAS Plus, is to the left, and down from the target.

EISELE From the target. That's right.

SCHIRRA One degree in each direction.

There is another thing on the COAS, I remarked on in real time I think. It is almost impossible to have that darned reticle show up against a cloud background over the earth.

EISELE Yes, it's not much good in the daytime.

SCHIRRA It is great for the dimout thing. I have

some more coming out of my mind now. I have this big song and dance from everybody that because the stars were not at infinity in the simulator and the way everything was boresighted in the simulator, the light loss in the simulator was not representative of the real world. I was going out of my mind up there using my left eye to see the star and my right eye to look through COAS. It was a great light loss through the COAS. They said it was because the simulator was like that and people ran studies and they ran that little star check back in Houston. Dean Grimm did it and you can see 6 and 7 magnitude stars and all sorts of stuff. If that is the case all I can say is, you see more through the window in the real world than I thought we would. And that is possibly true. I went out of my mind with stars like Fomalhaut and Alpharatz that are around first magnitude. Carrying them into the center of the COAS for that COAS alignment. So there is a great light loss.

CUNNINGHAM Well, we have to face it - the stars out the windows are fantastic.

SCHIRRA Yes, I think Walt's first observation, - all of us then, of course, saw it, the Magellenic clouds, proved a point.

CUNNINGHAM Yes, they were distinct. I mean it was about like the normal -- You know I looked at it for several nights in a row, kind of hesitant to say anything about what I was seeing.

SCHIRRA Did we log that airglow, that high airglow?

EISELE You've got it in the flight plan. You had to verify your sanity.

SCHIRRA Yes, I really needed help on that one. It was one of our mutual night watches. I saw the red arcs that I described in Mercury, and never saw again in Gemini nor did anybody else. And that is way above the airglow, about 5 degrees above it. I would say about 15 or 20 degrees above the horizon.

EISELE I think it is a little more than that. I looked out. I could see it over something like that on my side window. But it was a definite distinct layer. The separation between the two was - I didn't think it was quite that much. I thought it was about the same as the thickness

of the lower airglow and then the upper airglow was fairly wide. Wider than the lower one probably.

SCHIRRA — We spent a lot of time, by the way, with the COAS, while we are talking about airglow and the optics, trying to measure the thickness of it. It varies fantastically. Depending upon what time of day or night (space day or night) the night airglow was, I am pretty well convinced, somewhere around between 2.5 and 2.8 degrees.

CUNNINGHAM — I got one excellent measurement I would like to have somebody do the arithmetic on. I watched a star or planet 90 degrees to our line of flight, so from the top of the airglow down to occulting, and there should be no error in it essentially from our motion. I would certainly like to have somebody check that out.

SCHIRRA — Walt and I were talking about the time I took the planet Mercury and took it through, in Mercury, and they got all the information out of it. That occulting, you've got to remember, counts refraction. You can see below the earth.

CUNNINGHAM Yes, but refraction can be fairly decently calculated.

SCHIRRA I agree. I just mean I want people to make note of that.

CUNNINGHAM Oh yes.

SCHIRRA About a month after they said I couldn't possibly see Mercury someone realized it was refraction.

REP Well, I have the data and I will get it to the right people. I would like to have it.

CUNNINGHAM Okay, where are we on this thing?

6.8.9 Clothing

CUNNINGHAM Clothing, PGA. It is so nice to get out of it and it is so bad to put it back on.

EISELE It's amazing. Soon as you get it back on, you go back to your elephantine sychosis. Once you take it off, you ought to never have to put that thing back on.

SCHIRRA It's amazing. We lost all of our mobility. We'd go flitting about below the couches as you saw on that film. When we had the suits on it was a nightmare to go below the couches.

CUNNINGHAM It sure was.

SCHIRRA This was in the docked position. I could just barely get in the couch.

REP Let's go with the underwear here.

SCHIRRA The underwear is part of our biomed harness problem. They don't stabilize that harness well enough. It can move down 2 or 3 inches so the length of wires becomes kind of critical. At the same time I was just amazed to see that garbage all over Walt's chest. He had some leads that were 8 inches too long, others were too short.

CUNNINGHAM I had a rat's nest in there.

SCHIRRA My point is: onboard you have four sensors and we changed the sensor on Walt and that invalidated the biomed harness, so all this discussion was very academic I thought. We didn't have much time to argue about it or discuss it. The biomedharness is really a whole bunch of wires together. It is not one integral system as most people thought, and to change a piece of wire was not a big crisis. They could have made a wire the right length without disrupting the whole program or changing the characteristics of it.

CUNNINGHAM I think the underwear stabilized it quite well though. I would rather have it on the underwear than strapped to my skin. I thought at first I would like to have a third set to change into, but actually we changed about 7 days into the flight.

SCHIRRA That was a real treat, changing into that second set.

EISELE That really was.

SCHIRRA Well, I have got a point on this thing that I mentioned to the doctor and I think we ought to do it here. When you exercise with the seat belt on - in retrospect, I think we should have taken our biomed harness off.

EISELE Well, now that is a thought. I might take it off to exercise.

CUNNINGHAM The problem is that it is spread over a long period of time. When you and I were up, we would exercise as we could get it in. We might have it on and try to exercise over maybe a couple of hours.

SCHIRRA Do you think maybe the doctors will go along with not having that on and having us exercise? As long as we put it back on again?

SCHIRRA They shouldn't need biomed data while a guy is exercising. That research should be done.

CUNNINGHAM Incidentally, I had probably most of the marks of the three of us on those sensors after we took them off, but in all honesty, I didn't notice they were there during the flight at all.

CUNNINGHAM But in all honesty, I didn't know that they were there during the flight at all. Now, I do have a comment on the underwear, though. The trap door; there are two ways of having a bowel movement in there, either through the trap door, or dropping your drawers and getting comfortable.

SCHIRRA There's only one way in that sense.

CUNNINGHAM That's exactly right. I tried it the first way; I fought it out and did it the first way with that trap door back there. The trap door is tbo small for that, and it's so much easier the other way that we might as well not have a trap door. There is not a thing that that trap door in the back does, and I'd suggest that we don't have it.

SCHIRRA The flight coveralls, I would say off hand were fine. There is only one thing we discovered fairly late in the mission. The hole up here is different from Walt's because he's got a different setup on where his switches go. It brought this big blob of wire up here, and what I ended up doing, very late, was bringing the cobra cable connector through the middle of the jacket and mating it up there, and

that took all the junk off my shoulder. You still have that thing sitting out here like that.

REP I know but if you did away with that loop, you see, it would be down here.

CUNNINGHAM If you made your cable the right length, it wouldn't bother you. If the cable was right on the light-weight headset - The cable is too long, and they just simply doubled it over and it makes a big lump out of the side of your head. We had a make-work-fix on ours, and I think we should get away from that make-work-fix. It was irritating, and I caught myself twice during the flight with this thing sticking up, turning the wrong direction and talking to the wrong thing.

SCHIRRA Yes.

CUNNINGHAM You have this big thing set up like a microphone.

SCHIRRA The other thing I'd like to suggest is on the flight coveralls; that's what you are going to wear most of the mission. The pockets did not close up right; this Velcro game was not very

good. Little bits and things you want to get rid of, you couldn't keep in there, so you had to go somewhere else. Those blue suits that we came home in were the kind we used to fly airplanes. They have zipper pockets all over the place and you can keep trash in this one, and snot rags in this one. We just had two pockets on there, and a strap-on, theoretically, which still had a big hole in it. We didn't use the strap-ons at all, never used them.

CUNNINGHAM The strap-ons are bad pockets.

SCHIRRA We took our scissors out of the strap-ons, and we never used that pocket again, we snapped them to the spacecraft.

EISELE Well, the main reason that the strap-ons are not very good is that the flap doesn't come down far enough. You have this big gap; I think you need to relocate the Velcro or else put a zipper on that one.

CUNNINGHAM It was a problem, if you strapped it onto your leg with your flight coveralls on. It was just something else you had to unfasten to take the coveralls off, and nobody would mess with it.

SCHIRRA I forgot who promoted the idea of picking up debris with tape; I guess you did Walt, to get the garbage off the filters.

REP I did mention that to you preflight. That was to get Beta fibers off your skin.

SCHIRRA It sure was a saving device.

EISELE George Low said, "I've been doing it for years on my blue serge suits."

SCHIRRA My Navy blues, that's the only thing that can clean the darn things. We kept some tape up on the instrument panel. If we got a washer or a nut or bolt floating by, it was the only way we could trap it. Believe me, we were going out of our minds trying to hold this stuff. You put it in your pocket, it would come back out again. We'd put it on this tape up there, and later we would put it away. A piece of tape on the instrument panel is a great thing for a repository for a while. Then you can roll it up and stow it. That tape was pretty valuable stuff all throughout the mission.

CUNNINGHAM Incidentally, we would have used almost no tape throughout the mission except for the fact that

we used it to fix our head sets. That is where we used most of the tape.

SCHIRRA That's where the tape went.

CUNNINGHAM We thought we took that tape along to wrap the food bags. I did one food bag, where I put a piece of tape on it. With all the other food bags we wrapped up the food, stuck it inside the bag that it came in, very tightly incidentally, took the piece of tape that was on the outside of it, and just taped that bag closed. It was labeled, they knew it was your meal, what day, everything else.

SCHIRRA The tape goes on the outside of the bag, just to make the point clear, we were so used to it.

CUNNINGHAM It was a label for the meal. You can peel that off, and use it to wrap up afterwards.

SCHIRRA We just used a long piece of tape, not the little short one.

EISELE I think you ought to have that tape along, because it's kind of like having a pair of pliers, you know, all purpose type thing.

SCHIRRA Yes. That is something else we are going right into the COMM helmet. The microphone on the light-weight headset started breaking off, right

at the root. The tube started to break. I jury-rigged it right away in the beginning when I first saw it. I spent about an hour on it with the tape after that, and it held up throughout the whole flight, I had to rebuilt it. We wouldn't have been able to use it.

CUNNINGHAM That was the light-weight headset. I had one other problem with the light-weight headset. The tube that ran up to the fitted ear piece came off. Apparently it's supposed to be glued. I'm not sure that it ever had any glue on it, but it came off from the ear piece some time on the third day.

SCHIRRA From the molded ear plug.

CUNNINGHAM Yes, from the molded ear plug, and at numerous times throughout the flight from then on I would discover myself without COMM, because the tube would come right off when I moved my head.

SCHIRRA Interesting enough, we all three had different kinds of chin straps. One of the nicest things that happened, it turned out. At the last minute Marshall Horton gave me another kind of chin strap that was stuffed in my pocket. I'm

glad he did because on reentry, our beards were so irritating, our skin was so tender, that the chin cup did bother me. I used this alternate underneath my chin. My beard didn't bother me at all. At the beginning of the flight, that football player's chin cup worked perfectly to keep it stable, I gather Donn and Walt went along this line, too. But I think those three types of chin straps are in the inventory. Let the guys take their choice. Watch it on the plastic chin cup for return. Any of them are bad, and I think you really want to have something you can put underneath your chin when you have a beard.

REP Where was yours, Donn, for reentry? Where was your chin strap?

EISELE My chin strap? I wore it across my chin.

REP On reentry?

SCHIRRA But it did bother you? Remember I asked you that.

EISELE Yes, it's irritating, and it's bothersome.

CUNNINGHAM I never had any problems, it never bothered me when I had it under my chin.

SCHIRRA Yes, yes.

SCHIRRA To start out I had this cold and I was super sensitive to drafts. That was why I kept them on. They felt good there because they really are a barrier. They're not at all - porous is what I'm trying to say. So whenever the hoses were blowing, I didn't feel that draft coming through. I guess that helped me considerably. And I slept in them, but I was hot and sweaty and all that kind of stuff. As I improved in physical condition, I would say about the sixth or seventh night, I took them off every night. But I didn't do that earlier in the mission. We stowed them. We slept in the sleeping bag every time we went to sleep.

EISELE When we said free floating, they must have thought we were both on the couches - just floating around in the cabin. What they meant was we weren't hanging on to anything; we were just inside the bag.

CUNNINGHAM To us it was very plain. There was a significant difference between sleeping free floating - We learned a whole new vocabulary.

SCHIRRA In 11 days you do; so we have to be very careful the way we talk, I guess. To get it back to

our own guys even in lay terms. It's amazing, but that's what can happen in that length of time.

EISELE I thought the flight coveralls are very comfortable at times. I know on my watch when the spacecraft was powered down and everything was quiet particularly on the dark passes, on the dark side, at night it got pretty chilly. And I welcomed having those things on including the boots.

SCHIRRA You saw the powered down mode, so your opinion is really important.

EISELE I would recommend that you continue to take them along because you may find you get chilly without them.

CUNNINGHAM Well, I definitely recommend you keep the things too. I found them very comfortable to wear.

EISELE Well, you need the pockets too. You got two pockets and wings, and you need the places to stick your pencils.

CUNNINGHAM You use the pockets quite a bit. I wore mine during the day. I never wore them at night except one night when I forgot to take my pants off.

SCHIRRA Oh, really. We did discuss the pockets. They have to be improved for holding small objects. It may be that others will have colds, and that's why I transferred my Kleenex at first. Then we used the ORDEAL box for Kleenex stowage. It's perfect for it. That we labeled the snot locker. There's only two we should talk about I guess. They're the launch day UCD and the normal urine disposal. On the launch day, UCD we still dozed in the suit bags with the suits. We did not find a real good use for the UCD lamps. Think we can delete those UCD clamps? I never used it. In fact, I would propose we do if you have this condition, even if you wear the suit for 3 days, for example, to the moon. You take the UCD off, you take that roll on off, and you throw it away into the waste can.

CUNNINGHAM Yes -

SCHIRRA And you put a fresh one on when you go to use that thing again because you've got them in the medical kit then, three or four of them in there. That's the way to handle that guy with a launch day roll; just dispose it, don't use that clamp and make your mess with the Kleenex and

everything else and just dump the whole load and delete those clamps.

EISELE I didn't use the clamp at all. I hated doing just that. I got it out again with a roll-on that was all gummy, so I just threw it away and got a new one.

SCHIRRA Now the other thing, I'm anti-bead roll-on -

CUNNINGHAM I'm a very pro bead roll-on.

SCHIRRA The easiest way to solve that is to get the right size roll-on and have beads on them because they can always cut the bead off.

CUNNINGHAM Yes. Incidentally, to cut the bead off, it would have been very useful. I found that one criticism I had of the roll-ons; they did not retain themselves on the UCD. And I think if I'd of had a bead on that I wanted to cut off, I could have stretched it around there again and it would have stayed. Several of us had those pull off when we really didn't want to.

SCHIRRA I might add that I had one roll-on that was larger than the rest, and that's why I had trouble with that time. By the way, that's an interesting observation. Remember when they were trying at the last minute when they

were going to give us some smaller ones because they said we'd shrink. That's not true.

CUNNINGHAM No, I agree.

EISELE Well, I thought the UCD was convenient and easy to use. It worked fine. I didn't have any trouble with mine at all. I think I changed roll-ons about four times because after a while they developed little pin hole leaks, and you have to throw them away. But that isn't a problem either. You just slip a new one on and go.

CUNNINGHAM Yes, I had one roll-on that developed a leak. You apparently saw it when it started spraying.

SCHIRRA You had a pin hole leak, and it was coming right at me, that's why I saw it.

CUNNINGHAM But I found that it was not inconvenient to use. Everybody developed his own technique. I don't think that you necessarily clean yours the way I did. But it was quite a ways into it before I - you recall rinsing them out. It was the first water. We just kind of stuck them out thereby drying them out, and putting them back in. Wally had a very good point, they stayed wet inside, down there. I was always sitting there rerolling it, and cussing because it was

all wet with urine. And Wally, I noticed he kept sticking his away, and I said what's the story. He said well, I roll it when I need it. Then I don't mind it so much.

EISELE Started using the water gun to clean them out, and if you're careful, you don't get the water gun on the roll-on.

SCHIRRA In other words, if you use the water gun to clean the valve so it wouldn't get gummy, not the roll-on.

CUNNINGHAM You try not to touch the roll-on.

SCHIRRA But that did work out.

CUNNINGHAM I think that's a very important thing.

EISELE I think we had misgivings about trying that at first, but it's not a bit hard to break the water stream, and cleaned it out very well.

CUNNINGHAM Something that I did that I thought was very useful, it helped in that it was dry the next time that I started rolling. After a couple of days, it got so that I would take the Kleenex and I'd twist it up and stick it down in there. Which kind of dried it, and then you'd squeeze the roll-on on out. In other words, it'd be dry the next time you rolled it down.

SCHIRRA Stowage areas, I think what we said covered that earlier.

EISELE Yes, I guess the message here is that there's plenty of places to stow things, and you've got lots of options. And probably no two crews will do everything exactly the same, and that's fine too, because you set it up to suit yourself.

CUNNINGHAM There's one stowage problem we did have. You guys never saw it, but I did every morning. The place where we had the dosimeter and the camera bracket. The camera bracket was not retained tight enough in there. You'd open the lid up and the camera bracket would float out. We also had the O_2 partial pressure thing, and it just set there.

SCHIRRA I did have that problem because I was slapping it in there trying to get something else in there.

EISELE Yes, and it just set there. So we did have a piece of equipment that was not restrained. You know late in the game, we decided to stow it down there. That particular compartment wasn't restrained.

SCHIRRA Now that you've brought up the subject, we had

another problem. That was the lithium hydroxide canister, that block I version. We had to practically stress my couch to close the lid on that.

EISELE Oh yes. It was just the one container.

SCHIRRA Beneath my feet.

EISELE One beneath Wally's couch that we could not get the lid down very easily.

CUNNINGHAM It took me 10 minutes, and we finally finished the last hydroxide canister.

EISELE But the rest of them all worked fine. That was the only stowage container that we had any trouble with.

6.8.10 PGA Connecting Equipment

CUNNINGHAM No, I didn't have any problem with hoses.

SCHIRRA We had the Beta covered cobra cables and the cover right up at the connector and was really badly frayed at the end. No, that's not going to be a continuing problem because they are all black fluorel. I think our spare was black fluorel, in fact. We would have had those, but they failed through PIA at the last minute, and they didn't have any replacements. So we had one spare and that's all. As I understand it, the next mission will have black fluorel.

If they're not, this should be pushed for. We had lint stuff all over the place at the end of this mission. That's because this stuff was starting to fail. The hoses connected up with no strain when we got back.

CUNNINGHAM But we didn't have any trouble with plugs that didn't mate up or hose connectors.

SCHIRRA The only thing I would like to say about the PGA connecting equipment is that blasted cable that comes up underneath your chin, it drove me batty all the time I had it on. They tried to do something about it, but we're using a battleship cable routing for little tiny wires. And when you get to the BIOMED sensor, you got a little feathery wire and you get to where it connects to something else, it's a battleship cable. The thing sticks right in your neck and is very annoying.

CUNNINGHAM I've got another stowage problem, gang. Spare roll-ons and in R11 are not retained well enough. They are always floating free in the compartment.

SCHIRRA Yes, there's a well. It's obvious that if anybody looks at it. But somebody's got to fix it.

EISELE Yes, the problem that I had there too, was that when I need one, I had to reach in and pull out the little packs and usually I had to pull out all three before I got to mine.

CUNNINGHAM They floated around back there and I kept pushing them back.

EISELE It would have been better if they had been secured so you could reach and grab the one that you knew was yours.

6.8.11 Crew Couches

SCHIRRA Easily defects and odd defects, I found it very irritating. One the crew couches, it's sort of academic to discuss them. They work quite well. I was particularly pleased with the translation controller. It was fixed just right. Solid beam bar was much better than that rinky dink on that side. The one thing that we should register is on the foot pans. Donn had a real nightmare. And we came in with an open item really and he was in trouble.

EISELE My foot pan was not locked for entry.

SCHIRRA This was getting too late then to mess around with it. My foot pan was locked up on more than one side, and Donn was down there -

CUNNINGHAM Donn also had much trouble getting his left foot out of the restraint.

SCHIRRA Concerning this part, the other couches are going to be like that. Let's see, my outboard side of the foot pan wouldn't lock up. Is that right?

EISELE I can't remember which one.

SCHIRRA We started donning the couches at T minus burn minus 45 minutes.

EISELE Yes.

SCHIRRA And he got his foot so locked up in there, he couldn't get it out again. And Walt had to unstrap him, go down and get it back in again.

EISELE Then after Walt did that, that's when we found that my foot pan again was not locked in and by then it was T minus 25 minutes, and -

SCHIRRA We didn't have time.

EISELE We said to hell with it. We're going home. Well, the reason that I wasn't worried about it was that I had plenty of knee clearance in the center seat. I wasn't worried about jamming my knees.

SCHIRRA We discussed it, if we were really worried we were going to go around one more rev.

EISELE — It was inconceivable to me that the couch would ever stroke far enough to run my feet into the LEB. You would have to go 2 or 3 feet there before you hit anything.

SCHIRRA — Donn has this big open area above his knees, so we weren't worried about it. Walt and I didn't have that kind of area. If it had been Walt or myself on the same foot restraightening, we would have scrubbed that retro and taken another rev. That's how bad it was. I'm sure if Mission Control had known the recovery weather was that bad we would have gone ahead.

6.8.12 Restraints

SCHIRRA — Hand straps - that's absolutely a waste of the material.

EISELE — That's a good item for deletion as far as I'm concerned.

SCHIRRA — Take the labels, handles off as well. The EVA boys think you've got to have handholds all over the place, and the IVA boys, we three only, say we never use it. We used wickets. Walt had one classic experiment with a circuit breaker, and moved all over the place and didn't even actuate it. We're trying to make it quite clear we did

not actuate one switch, pull, or depress the circuit breaker that was supposed to be out, ever, for the whole mission. Not one -

CUNNINGHAM Frankly, we had our backs against the MDC time and time again.

SCHIRRA We were doing flips. We never knocked a thing -

EISELE Oh, we floated into the switches now and then but we were moving so slow, and the wickets protect them so well -

SCHIRRA The only important thing we had was that hand controller.

EISELE When we talk about handholds - we're talking about the ones on the struts down here. The one that's under my knees, incidentally, I used every time I tried to sit and get into the couch. Not zero g, one g.

SCHIRRA You get trapped in the one g world. That's the point.

EISELE They're great for the one g, but you don't need them in orbit that much.

CUNNINGHAM You've got three up there though around your -

EISELE The center one is the only one that ever got grabbed at all, and I'm not sure of that.

SCHIRRA Well, we tried to delete the ones on the struts and the other guys, EVA people, said you've got to have them.

EISELE They're redundant - they're probably more redundant than the dumb Brooklyn Bridge structure for the hand controller. I don't know what the G&N station restrain is. Does anybody know what that's supposed to be?

SCHIRRA That's the foot -

EISELE Oh, is that Velcro on the floor? That didn't work out too well because there is enough torque or set or something into the COMM cable which tends to lift you upperward away from the floor when you've got it on. It just pulls your feet right off that stuff, and you don't need it anyway. The film shows the normal position that you assume when you work the G&N controls down there and you've got your buttocks against the edge of the center couch and you got your two hands on those handles and that's all the restraint you need.

SCHIRRA The other thing I would like to make note of because we talked about earlier - that strap thing. If it were on the spacecraft, I wouldn't

out looking for it. If it just happened to be there -

EISELE What strap?

SCHIRRA The series of snap straps that -

EISELE Oh yes.

SCHIRRA I'm sure I could learn to do without it. I just got into the habit of using it. And that isn't required. That was also part of the G&N restraint. It was secure around your waist and hook on to things.

CUNNINGHAM Another thing to keep in mind, people getting ready to go into this IVA environment is the body really likes the fetal position. You don't get quite into it, but if you're standing relaxed doing anything like G&N station, Donn was in the fetal position.

SCHIRRA Your whole body relaxes for you with your knee coming up and you go into the fetal position.

EISELE Yes, the no-load configuration of your body is just that.

SCHIRRA Sleeping restraints, there were some straps in the sleeping bag, but I didn't understand that at all. There was only one around the waist.

CUNNINGHAM Those were for sleeping on top of the sleeping bag. I'll tell you the benefit of the sleeping bag.

SCHIRRA What was the strap up at the head there that hooked on to something?

CUNNINGHAM I don't know what that was. Early in the game I was one of those advocates who would say we don't even need the sleeping bag. Go strap yourself to the bottom of the couch. One benefit to the sleeping bag - it allows an inanimate object that's asleep down there to stay located in one spot so the other guy that's awake doesn't keep pushing him around to get him out of the way.

EISELE Keep him from floating away.

CUNNINGHAM And I'll tell you along those lines, there's something I didn't like about the sleeping bag if you're going to have it at all. The straps that retained the feet joined the sleeping bag up about -

SCHIRRA About 3 feet up the back from where your feet were.

EISELE That's right.

SCHIRRA Towards your waist.

EISELE I would have preferred that the bag had the straps out each end.

SCHIRRA You want the sleeping bag to be a cocoon. To move around inside the sleeping bag but don't move the sleeping bag around.

CUNNINGHAM That's exactly right. And that was irritating to me at that -

EISELE I never did understand why they built it that way.

CUNNINGHAM Do you see what we're getting to on the straps?

6.8.13 Flight Data Files

EISELE I thought they worked out very well. A tin box by Walt's elbow, and the -

SCHIRRA We just had the one compartment. We deleted the one on my side; we didn't need it. The only cards I carried were those flip cards in the - on the sixth rev thing.

CUNNINGHAM I think we had adequate inflight data stowage. The only thing about R12 on the right hand side, it was an individual tuning pound so to speak for spacecraft 101, but it had two metal hooks to retain the bottom of it and a strap on the top and one hook was always coming out. It was kind of catty wampus loose. It's the kind of

thing that should have been mated a little better. On the flight data, we ought to mention that. We carried a half a dozen clips which was not enough for one for each hook. It worked out okay for us; everytime that Donn was awake, we could collect from him and start all over. Very handy, you could use them to hook - hook it to -

SCHIRRA The flight plan on top of the master caution panel. The flight plan was out all the time. Everybody had access to this because we lived with this thing as you can see.

EISELE Yes, the flight plan was out constantly.

SCHIRRA You've got to have a reminder. Just like you fly, this is your knee board.

CUNNINGHAM Yes, it really is, you just refer to it all the time.

SCHIRRA I think it's interesting to look at our flight plan with the stuff that's in it, and the CAP COMM's a lot of stuff in that too.

EISELE This is part of the data file right there. Those clips were really handy for holding checklists onto the wall and keeping your place in the book at the same time.

SCHIRRA That's the only solution we know of for a book with many pages. Now for the little six rev one, I think that's a good technique that would be the kind of thing you might take with TLI, for example. I'd hook that, because we hadn't learned the clip technique yet. I'd hook that to one of my wickets on my left side; the clip technique made it a lot easier for me. Okay. We made all our burns in the docked or rendezvous positions.

EISELE Except the deorbit.

SCHIRRA I'm sorry. Except the deorbit, and, of course, boost. We didn't have our foot pans up. We had the leg pans down to the - break of the knee. On two burns, I was in the right seat. I'm not sure if that was true of all the other burns - at least the headrest was down and I just slid down the couch a little ways and braced my head there.

CUNNINGHAM I used one shoulder harness -

SCHIRRA The first time up we did the first burn, we had shoulder harnesses on, we had seat belts on, we weren't sure we weren't going to do this the rest of the mission either.

We didn't get exactly supercasual about those burns.

CUNNINGHAM — No. When it got time for the burns, I'd try to force myself against it so I didn't get snapped.

SCHIRRA — Yes. It's like a catapult shot. I think that's the same when you know that you gotta have your head back or you're going to get snapped.

6.8.14 Inflight Tool Set and Workshelf

EISELE — Well, there wasn't any workshelf. We threw that off a long time ago. I thought the tool set, for what little we used it, was fine. The only thing we used out of it was the wrench, because we had a spare E tool anyway.

SCHIRRA — Didn't we use a long adaptor for one deal?

EISELE — Yes, we might have one time. Yes. When you were taking that panel off to get back to the water.

SCHIRRA — Yes.

EISELE — Where the water was on the pipes. It was fine. It held the tools in place properly, so you could get at them whenever you needed it.

6.8.15 Food

SCHIRRA I think the food has been discussed appropriately with the doctors, but I do feel we've got to play the food much more carefully. This is wrong to save weight in food by bringing up the caloric intake of the food with sweet things.

EISELE I've summarized it by saying, "Don't load up on bite-sized too much; don't load up on beef bites."

SCHIRRA Boy, he was so anti-beef bite, it was unbelievable -

CUNNINGHAM - Don't load up on calories - 2000 is plenty and I feel that very strongly and I was converted. I've got another note here which is slightly facetious, "Try to take two breakfasts and one other meal." That's because the good stuff seems to be at breakfast -

SCHIRRA Well, the real point - and the crews may not get this from the doctor's report: First, you're suffering from a bland diet - there's no salt in it. And, I think that's one reason why we craved the bacon cubes so much, we wanted salt.

EISELE Yes.

SCHIRRA And I'm convinced your system cries for stuff it

wants. We also craved chewy stuff like, but not this crumbly stuff, meat type of stuff like beef pot roast or reconstituted meat stuff, that was so palatable. The warmed food is a whole new world. I'd also like to add that the coffee should be changed to a better kind of coffee -

EISELE - a better brand -

SCHIRRA It was a high for me whenever I had it.

EISELE I wish I'd had one every meal like you did.

SCHIRRA Yes.

EISELE I had one for breakfast. But that - ought to be a crew option and if a guy wants coffee every meal, he ought to be able to have it, too.

SCHIRRA Yes. It's not a big deal - just a very thin little teeny line.

EISELE You know I was - we mentioned this before flight and decided not to bother, but I'm just wondering if vitamin pills might not be of some use on a long mission like this because -

SCHIRRA As a supplement?

EISELE Yes, I think we tend to get run down. For instance, our colds might not have been quite

as severe if we had had a good supply of vitamins. Another point about them -

CUNNINGHAM - And particularly if you get up there and don't eat all your food -

EISELE That's exactly what I was going to bring up. The doctor says, "No, you've got a balanced diet."

CUNNINGHAM If you eat it all, maybe you do.

EISELE It comes to the point where you're not eating all that balanced diet -

SCHIRRA You know what they could do - and let's make a note of that. I didn't make it to the doctors. We didn't put the bacteria pill in the juices, because we felt that wasn't required. We put it in all of the reconstituted food that could develop bacteria and explode. Maybe you could put a vitamin pill in there in lieu of one of those yellow pills.

CUNNINGHAM Oh, I see.

EISELE Just make sure you don't get mixed up and eat the wrong kind.

CUNNINGHAM You know I kept a meal for 2 weeks in my desk drawer to see if it would swell up and it didn't.

SCHIRRA It didn't?

CUNNINGHAM No.

SCHIRRA That's a nasty routine to put that pill in there.

CUNNINGHAM The other thing about those pills is they're just like rocks.

SCHIRRA Yes, but you don't have to break them, they do melt with just a little bit of moisture that's in that little plastic bag.

CUNNINGHAM Yes, but we eat the meal before they melt.

SCHIRRA You're right.

CUNNINGHAM A softer pill, it's got a little coating on it. Put it in and squeeze it.

SCHIRRA I guess what you're saying is, we shouldn't mess with the pills at all in any of the food. With the work loads, it's a nuisance. Because you have to cut the bag - get the pill out and hold the pill, open up the mouth spout again, stick it down in there and squeeze it inside.

CUNNINGHAM Some of the foods sustained a failure of the type like the bite-sized or some of the cinnamon bread cubes. One of them would get crushed, and I think this happened in packing, you know they're generally pretty strong stuff, but in packing you might have one little meal

that's got broken and then you didn't dare take the meal apart. We did a couple of times and all the crumbs would start coming out. Another thing is we had several food bag failures - reconstitutable food bags - between three and five.

EISELE — You were the one with the bad luck. I don't think I had a one fail.

CUNNINGHAM — Yes. Well, one failure was very interesting and at the place where you're supposed to be able to get the spout to eat out of, it had no opening into the bag. It was completely sealed.

SCHIRRA — That was the foldup spout?

CUNNINGHAM — Yes. I had two other bags that failed in a way that - the material would squirt out not through the spout but through the next layer, and you ended up with a mess. Generally, the food bags lasted. I was surprised we had so few failures really.

SCHIRRA — Well, one of the keys that we found was powdered food in the food bag drifted around the bags, it meant the bag lost its seal. It's a good quality control check. Not for us in flight - it's too late then. Preflight if you see food,

powdered, moving around in the bag, it means it's a bad bag and it should be sent back for evaluation. We didn't see any like that. Remember earlier when we had those sample deals?

EISELE Yes.

SCHIRRA Some of them were like that. The other thing that was done towards the end of the mission - I'd use the water pistol trigger to fill a used bag and drink out of that.

EISELE Yes. I'd save the fruit juice bags.

SCHIRRA Yes. I never seemed to remember to do it. Eventually, I just said "Aw, to heck with it." Wrestling with a gun is a lot of work.

EISELE It makes your thumb sore.

6.8.16 Personal Hygiene Equipment

SCHIRRA How about personal hygiene equipment? I'd like to add right away, Donn saved me, both Donn and I have hair that's long enough to comb and that comb was really a high point for me. It sort of massaged your scalp a little bit and it made you feel a little bit better each day if you could just see yourself looking --

EISELE Yes, we each had an aluminum pocket comb on there -

CUNNINGHAM I knew they were combing their hair because I kept cleaning the lint off the hoses.

SCHIRRA You were shedding more skin than we were hair.

CUNNINGHAM You know, I shed skin when I got back.

SCHIRRA I know. I saw your arms.

CUNNINGHAM My arms, my back -

EISELE I liked the dental equipment on there. I sure liked the toothbrush and the toothpaste.

SCHIRRA I wouldn't delete the dental floss though none of us used it.

CUNNINGHAM I noticed nobody used it either. In fact, it started catching on some of the Velcro.

SCHIRRA Yes. But I think there are people who have the habit of using it, and I'd rather not change that factor.

EISELE Yes.

SCHIRRA It didn't get in the way other than your point there, Walt.

CUNNINGHAM No, I thought the dental equipment was very satisfactory.

SCHIRRA I might add, though, if you did use dental floss, I don't think you would do it again after you were through with it.

CUNNINGHAM String was a problem - whenever we had pieces of string it was a pain to get all together in one gob and stuck in.

EISELE Oh, that's an interesting point, regarding towage.

SCHIRRA Yes.

EISELE We used the stowage box for the ORDEAL unit as a flight location for the Kleenexes after they were used.

SCHIRRA And for little teeny things, like the pill things we used the slit in the waste can.

CUNNINGHAM Yes. One thing about it - we might make note of the fact that we had seven towel bags and I found that was enough. I had one extra clean one when I came down.

EISELE Towels were great.

CUNNINGHAM The other thing is that we had two boxes of paper towels on prior to flight and we ended up with one left but we'd have been one shy for our particular mission had we not added the two.

SCHIRRA In addition, someone else may go who has a lot more bowel movements than we did. We had a low number. Particularly my two in there that averaged it down.

EISELE Was it five, four and two?

SCHIRRA Yes. You use at least 4 to 5 Kleenex per bowel movement. More likely five. That could have eaten into that box if we didn't have that last one. I think we just had enough is what I'm getting at. Course it was the colds that ate them all up. I also - I personally needed to use that little stimulus on the end of the toothbrush.

EISELE I used it, too.

CUNNINGHAM Yes.

EISELE I used it whenever I thought about it.

6.8.16 Personal Hygiene Equipment

SCHIRRA — There are differences of opinion about the little wetwashes with the food. Walt used them to clean up after waste management programs, I guess. I decided all of a sudden I was collecting too many of them. They sort of supplement the towels, if you keep a moist towel. Again, we're talking about something that is very optional. They're not objectionable. They're packaged and I don't think there's any sense in pulling it out at this point.

CUNNINGHAM — If you use them though, it's almost impossible to keep up with them. There's one every meal, there's one in every fecal bag and it's not too hard to find out all of a sudden you've got six sitting around.

SCHIRRA — You rathole them, you know for a big event or something like that. Next thing you know they're all popping out.

CUNNINGHAM — I do have a criticism on those. Some of them I used were moist and nice. The others were just like they had been on the shelf for months and months and were almost dry.

SCHIRRA The problem there is you can't get a little bit of moisture out of the gun, you have to take a whole shot. You couldn't rewet those.

EISELE Whenever you wanted to wet something you'd take a big towel and catch it out of the good station. That hot water. The only thing that is wrong, I guess, and I don't know how you could handle it - we started collecting a lot of hair in that cockpit. Body hair, whisker hair, or hair hair.

CUNNINGHAM This might be an appropriate place to digress and talk about combing the hair. We did make note of the fact that when Wally and I got up in the morning, it took about 45 minutes from the time we got out of the sack until the time we were laying in the couch ready to go, with all our COMM on and everything else. That 45 minutes was used up for such things as rolling up the sleeping bag. I'd take a radiation dosimeter reading, we'd both get a chance at the urine disposal, take a towel and wipe our face off, get dressed, get our COMM all hooked up, comb our hair, and in general get to the point where we're really with it.

SCHIRRA In the spacecraft, you're expected to perform right now and answer up with sharp answers and face up to the day. I guess what we're trying to say is when a man comes off the off-watch, the way the menu was set up, you were supposed to eat and go to sleep right away which is not the way we do it on the ground. We did shift off that program to a reasonable breakfast, lunch, and dinner with a block of 16 hours in there.

CUNNINGHAM Incidentally, that 45 minutes getting ready to go didn't include any breakfast and I'd say 45 minutes comfortably. I think that's non-plannable for the flight plan. I really do. Just like the meals cannot be blocked out like that. You should allow the time, but specifying that this 30 minutes is used for eating is almost a laugh. You just never eat in that 30 minutes.

SCHIRRA Well, each bag for example Deke, takes you 5 minutes to get the water in the bag. The bag will say 15 to 30 minutes for reconstitution. Right there, you've had to drop something to do that.

CUNNINGHAM Every once in a while it was quiet enough so we could finish eating in 45 minutes, an hour or so. Each meal took a couple of hours. You kept doing other things too. We had the food out and we would go about the normal tasks and keep eating as we did them.

SCHIRRA One of the things that kept us ahead of the time line, which was not in there, Donn started the day a rev early, and that's how we always held our heads up. He would go out and get a P51, at least a P51, and get the spacecraft constrained in some kind of attitude. That last day, our time line was about 3 to 4 hours from the published flight plan. We put that much more in it. That particular series was tight right down the line. It was tight all the way down. I'd say in show biz words we were over-booked all the way home. We really were.

EISELE I think the way we had it planned out though was close but it never pushed us over. Do you want to go into the inflight exercising. I think we probably can handle that one between the two of us.

SCHIRRA Yes, I think Walt and I were real fans of it. Walt almost went into shock when he saw me use it so much. It just made us feel good and that's the whole point. You need a device to work on, there really isn't a good place to work against the spacecraft, you just can't get stress going in there.

CUNNINGHAM I think we were thinking that - and this is differing from isometric, now you are long enough to reach clear across the spacecraft and push on the two walls, but isometrics doesn't give you the satisfied feeling that isotonics do. I think at the time we felt like we were going to have all this work to do moving around in the spacecraft and it just isn't any work.

SCHIRRA There's no work. That's what's so disappointing. That's why you hear us say, let's go from 2900 calories down to 2000 calories. Now I had 24 and I gave a lot of it away.

EISELE I thought you said you had 2000.

SCHIRRA Yes, 22 - 23 somewhere in there.

CUNNINGHAM I had 2500 calories and that was a mistake.

SCHIRRA At any rate we used the exerciser, unfortunately the film didn't show too well. We hooked fixed

straps on the hand holds, either the left or right seat above the left or right hand as appropriate ... and pedaled down in the LEB from the left couch on one side or the right couch, ... to the point where it got hot, ... You couldn't touch the capstan.

CUNNINGHAM Another variation of that is if I held the hand holds in my hand, I found I got a certain amount of isometric and probably isotonic, too from pulling on that thing. To a much lesser degree, Wally and I both utilized the hand holds on our feet and pulling on the ropes. I think I did that mostly just to even up a little bit. We both must have had in our mind to keep the legs moving for the biceps.

EISELE At any rate we can't endorse too heartily having an exerciser on board and we've all covered, in our debriefing with the doctors, the fact that if they really have our best interests at heart, the object is to keep the protocol out and allow this a free running business.

7.3 Visual Sightings in Orbit

SCHIRRA One thing, Walt saw a - well go ahead, Walt.

CUNNINGHAM Well, I saw a satellite and at the time I saw it, we logged it on the tape. Neither Donn nor I was aware that those were not supposed to be mentioned live over the air. Wally brought it to our attention. I logged it on tape. It was a satellite passing through the Southern Cross.

SCHIRRA Let's make it clear that this is a far, far away thing, much as you see from the surface of the earth.

CUNNINGHAM Right.

SCHIRRA We did not see, at least I don't recall and I don't think Donn ever mentioned seeing, anything that had recognizable detail other than those things that we took with us.

CUNNINGHAM Never.

SCHIRRA Geographical landmarks, I'd say were covered completely by film. The only thing that surprised us was one of the Apollo landmarks, and Walt was doing that one.

CUNNINGHAM There was a bridge across the inlet and it wasn't on the landmark map. We had what was considered a fairly recent map but there was a point of land coming out that had been bridged, very definitely.

SCHIRRA I'd like to make a point, Deke, so that our directorate gets straight on these landmarks and they put a date on when it is most current. The last time it has been checked out. This was one of these not too far away places, another country, but we almost blew the landmark. It was wide open weather and I was sitting up there in the window looking at it. Donn was looking through another window and Walt was down below and all three of us finally decided that was it. We took a picture of it and if it comes out we'll document that landmark. Cloud coverage, we had a lot.

CUNNINGHAM Wally and I did quite a bit of work looking at air glows day and night and trying to log them. I think, many times, that we got descriptions on tape and during that sunrise, I went live with trying to get the colors of the sky.

SCHIRRA I'd like to get that red arc thing and document where it was. That's going to be a job.

CUNNINGHAM This is an appropriate place to bring this up. Wally did see the high air glow again and I saw it, too. (Laughter) ... other celestial sightings. I didn't realize they hadn't been

seen before, but I had some very good sightings on the magellanic clouds.

SCHIRRA These had never been sighted before.

CUNNINGHAM After I realized I'd been looking at them for several different nights, I called Wally's and Donn's attention to them and I think everybody saw them.

[redacted]

8.0 EXPERIMENTS

CUNNINGHAM — Okay. We're down to 4. Cytogenetic blood studies.

SCHIRRA — All right. Now I finally agree; we had a pretty long knock down drag out on that particular experiment. An invasion, I call it, it is radioisotope. For the other crews' benefit, we bought it. One of the reasons I finally bought it was that this imposition would not be made on a "spec" lunar mission, if I can call it that. The experimenter, Dr. Johnson, is with me on this and is perfectly willing to negotiate this. I suspect if the next mission goes as we are thinking, that they may need this just to close the loop and that might not be a bad way to do it and get it over with. I don't think that crew is going to undergo any higher risk than we are except they're just farther away. I would almost say that might be a good place to knock off all that stuff.

[redacted]

8.2 Synoptic Weather Photography

SCHIRRA I guess we should, in this area at least, mention the cyclonic effect which we saw in the clouds. After Gladys, the tops of thunder storms in South America looked just like the eye of a hurricane. You could see the very tight vortex effect. We did get a couple of good fixes on it. Whether they turn out or not is another thing. It's a phenomena I have never heard reported before. Maybe people know about it. I was quite surprised to see it. This just brings up this area so someone can get into it.

SCHIRRA By thruster fires at night, you could see the pitch and yaw and roll. Particularly those that fired forward.

CUNNINGHAM I might mention that I couldn't tell which thruster was firing by the glow on my side.

SCHIRRA — It did affect sighting but you just stopped firing.

CUNNINGHAM — We also had sparklers coming off the thrusters when you fired.

SCHIRRA — Wait did make an attempt to catch an SPS burn with the movie camera in place.

CUNNINGHAM — Apparently didn't get a thing.

SCHIRRA — I think, on that thing, we're going to find out what magazine we used. We'll go back and see their master print and we'll look for something on it. It's very dim light, we know that, we'll see what we can find out. We just ran wide open, it was a fiftieth at two, to see if we could catch it. You know we always worried about that kind of stuff.

EISELE — One thing about it, we made a lot of burns at what would be considered local night, and I don't ever remember any disruption of out-the-window views.

SCHIRRA — Well, my point is we always worried about trying to hold attitude with stars or horizon. I don't think we could. Those views were awfully bright.

EISELE — The thing about it, you know, is we were always IFR.

SCHIRRA — I know, that is what I am trying to say. I found that I would have had trouble looking out if I had to do an SM RCS deorbit thruster firing toward the command module, not the service module. CM RCS thrusters really were bright. Even during re-entry we got bright.

CUNNINGHAM — It was a real bright pink cloud.

SCHIRRA — Oh, pastel sky, I never saw that before.

CUNNINGHAM — You know I mentioned that to some of the Gemini guys though and Tom mentioned that he had seen it. Very faint pink, well before .05 g.

SCHIRRA — Yes. Just like everything went pink. Just like light pink paste.

CUNNINGHAM — He mentioned where it was, too; I am sure that they saw it.

SCHIRRA — I just never looked out that way, I guess. There are so many windows. You can see all five windows with pink cloud.

8.5 Lower Body Negative Pressure

SCHIRRA — I feel this should be cancelled out altogether. It's a half an hour wasted every time you do it and you do it too often. I worked very hard to make it repeatable, not moving around and fouling them up. There are three things that this experiment is going to come up with: one, that

you change because you go into space. I'll concede the fact that you do, because you also go into pure oxygen environment. Two, that you need to exercise, and we concede that fact because we are exercising. Three, that you might want to wear some device around your legs to stimulate your lower body by having a negative pressure across it. That is objectionable and not a practicable solution, so the experiment only validates something we know. I see no reason to continue proving something we know. We know that pure oxygen environment is against us. It has to be because it's not the way we live.

CUNNINGHAM Another aspect of it is just the lying down, not zero g, just inactivity.

SCHIRRA I think it's a lot of fun to collect data on this but it's a great imposition to lie in that thing, on the ship, on the bench. The postflight physical just takes too much time. Most of it's experiments. We went right along with them and co-operated all the way so we could try to get some of this stuff out of the way, but that's the one thing we ask. I could tell the crews are looking at us. If we bought them, they say

they're going to have to buy them. I hope that isn't the way it turns out. I think we can probably knock off M011 and M023 without any great crisis.

9.0 PREMISSION PLANNING

SCHIRRA Okay. Premission planning and mission planning, I think, was pretty well firmed up right from the beginning. We didn't have any great perturbations in that. The only problem was that the trajectory kept changing. I cannot forget, even now, how all of a sudden SECO changed at the last minute and everyone was aware of it. We were flexible enough, almost flexible enough I'd say, to respond. In the flight itself when I didn't hear the Mode 4 call out, I was wondering whether that late change caused it or the transmission wasn't good. It turned out transmission wasn't good. But all the simulations we have done, we've done with the 9 plus 53 SECO and that would really eat us up in later missions. This is a pretty casual one because we know how to earth orbit pretty well.

SLAYTON We got the loop closed on that.

SCHIRRA In the flight plan, all I can say is that we had a pretty well defined flight plan and we kept

bringing it down to the point where everybody in the country had a copy of the flight plan that we flew. I went home and saw one; I saw one in the hotel; they were all over the place well before the flight. Fantastic distribution.

CUNNINGHAM I've got several comments on the flight plan, though.

SCHIRRA The premission planning or real time?

CUNNINGHAM No, the actual flight plan we flew.

SCHIRRA Listen, that's in the next area.

CUNNINGHAM Okay.

SCHIRRA This is premission. The changes to the spacecraft did bite us at the end. The battery problem bit us in real time, and that just happened to be a late discovery. I agree with that. We were very concerned about the foot pan changes at the last minute, and that bit us at retro. I think we froze up pretty well. There weren't many open items. The EMS, at the last minute, failed. I agree that we shouldn't change it. I think we can get around that because it's not necessarily space important to check that out. You can check it out with the centrifuge.

SCHIRRA — For example, we went out of our minds trying to find that banana plug that worked on the canisters. We couldn't find it, and frankly we cheated. We just held the can and the structure, which was just as good a ground as any wire.

CUNNINGHAM — We changed the first canister without it.

SCHIRRA — Two thirds of the way through the mission, the thing broke anyway. So we ended up going back with what we had done in the first place. This is the kind of stuff that can happen. That was pretty fast response for a period of 10 to 12 days. I know when the event occurred; it was in the 103 chamber. Towards the end, you just can't afford these changes, which is what I am trying to get at. Casual changes take a long time.

9.4 Mission Rules

SCHIRRA — I think we've had a real good exercise on that; particularly because of Walt's many, many Saturday working sessions with Glen Lunney's assistant's controllers. I think Walt spent as much time with John Arion as he spent with Donn and I going over Mission rules and systems. So we were in very good shape. I think this is probably the reason we were as reluctant in flight

to bow out on systems discussions. The knowledge that Houston had in the Mission Control Center was no less than ours. All of the malfunctions were done by the flight crews. In other words, they were hammered through by Jack Schweigert, with Walt working on them.

CUNNINGHAM I think it is significant to mention that point here, because I made a big effort to have a joint operation of this system. I say joint, in that, routine FOD, ourselves and John Arion were in favor of it. We had working sessions where I knew what John Arion thought about it and we agreed. As a matter of fact, we never had any big discrepancies in our thinking. For example, this accounts for the procedure for servicing a secondary evaporator. I knew that was a big surprise to John, too. I didn't have to call out and say, "Hey, John. What do you think?" Because he had been working along with me for a couple of years to try and obtain a way to do that. So I heartily recommend - and I don't know if anyone will be inclined to - but I think the people on the ECOM system are the best help you can have on the Apollo Missions. You just

can't operate it by yourself. They saved me time and time again, by asking, "Hey, you guys still purging?", when we got all hung up on something else.

SCHIRRA We discussed that particular subject. The real problem that is going to come from this is now that the malfunctions are done, they could be modified. There is going to be a difference; but on the first flight you can afford to work extra hard to guarantee that the systems will be good. However, the next crews that come along don't know how John Arion thought about that subject that day because they weren't in that meeting. So this kind of process will soften a little bit, where the next guy in the right seat is not going to be able to talk to John Arion. This is what I am trying to get across. Walt could always see John Arion sitting at the console and remember the meeting where they were talking about that subject. So apply to John Arion what you remembered of the subject and perhaps John might remember something that Walt forgot. I could see this very plainly all of the time.

CUNNINGHAM I've talked to John Arion twice since I have been back and several times he commented on a couple of things he had passed up because he knew he had to, but he knew I was already working on it. I think it is a great working relationship; I really do.

SCHIRRA That's part of the reason why we felt a lot freer to talk to these guys; because we had worked with them. We also spent a lot of time with the flight controllers. So much, that we lost sight of the fact that we were talking to each other. But we didn't realize we were talking to the world about our inside work.

CUNNINGHAM Another big plus as far as the mission rules went: we have a lot of things to review, and it helped greatly for Glen Lunney to have these working sessions with his people and everyone else concerned, even if we weren't there. He would send out a note of interest that described what went on at that meeting. Also, he put out some summaries; the Summary Flight Plan was absolutely a dream. It was the greatest thing. The Summary Flight Plan and Summary Mission Rules aided us tremendously.

SCHIRRA As a result, when we had our mission rules review in Houston on Monday, we were done in about two and one half to 3 hours. For first flight, that's unbelievable. We used to go for days on this stuff. We've worked our way along quite far since then, and Jerry Griffin has condensed those mission rules. He had a whole new format for mission rules. I don't know whether you noticed it or not, but you could read the bold version and then you could go back through it in depth and get the numbers in two sections. That was a pretty, little, short version.

CUNNINGHAM There were two things that I carried around with me all of the time; the Mission Rules Summary and the Summary Flight Plan.

Premission planning: some of these items do have to do with preplanning. For example, the food and the eat periods as compared to the sleep periods. We've probably mentioned the fact that they were pushing our daily cycles all over the place. Wally and I got to bed about 4 or 5 a.m.

SCHIRRA We brought this up yesterday.

CUNNINGHAM Now, the food: they've got to change from the scheduling and put the eat periods immediately prior to sleep periods.

SCHIRRA I brought that up, too, and you're right; that's a very big problem.

CUNNINGHAM In regard to ACQ and LOS times, we mentioned the orbit change, but we got to the point where our ACQ times were 4 minutes off and we were really running pretty much according to preflight trajectories. Yet our ACQ and LOS times didn't seem to be reflected here.

SCHIRRA This is what bit us. Remember I said the trajectory had been changed all along and that burn number 3 changed our ACQ and LOS times. Even our 50 foot per second changed it a little bit. The point is, we take our flight plan up and that's our knee board, and if it's off, we keep correcting it. By the way, I should add, it was good technique. Our guys used it in giving us the time of the next ACQ because then we would update our flight plan. We covered that in the sims, and that was one of the things

that we got out of our sims. I don't think you want a total update on that. Do you see your mercury at 5.6? That's all they did; and, if you were really interested in it, you filed it.

REP They were also pretty good about calling up and saying, "We've got you and we're standing by."

SCHIRRA It's funny how we got in the position of wanting to acknowledge, but they gave up, at least on Tananarive. Did you understand that we could hear you every time in Tananarive? We couldn't seem to get back to you.

REP Yes, we were listening.

SCHIRRA That's amazing! We went right over the place. We were able to see the station.

CUNNINGHAM Still on flight planning and premission planning. A note I made, after Wally and I had our little no COMM, Wally mentioned yesterday the no COMM.

SCHIRRA Wait, that's here in mission control and I've already worked that one out.

CUNNINGHAM We had an agreement before flight concerning the no COMM landing sites in the flight plan; but we didn't find it square in making that complete. We had block data on board for

six revs, but our no COMM landing sites were like twelve revs up.

SCHIRRA — Walt is trying to say that we really had a whole 24 hour update, GO/NO-GO, rev by rev, but no data on board. No rev on that last clearance. Walt was cleared, we'll say, to the eighth day.

CUNNINGHAM — Here is it cleared to 35.4 after 24 hours, for example, and we had block data on board for through REV 24.

SCHIRRA — Something might have happened in that period, and we got past the six rev block, which is what we did one night. I said, "Walt, by the rules, we should go home right now ", and we'd be dead if we were going to do it. Donn was asleep and we would start killing time by discussing it. That's why I wanted him to log it; that is, you are "out on a limb" and you expect that. This is too much of a problem, on the lunar mission. You've got one rev.

CUNNINGHAM — What I am saying is: the no COMM voice procedures what we had agreed upon before flight must be elaborated by having some data on board for the rev that you are cleared to. It can be done very easily.

SCHIRRA If you make a burn, you're going to update right after it.

CUNNINGHAM Yes.

SCHIRRA I think this is something we can sit down and talk to Glen about. This has been annoying me and I do want to talk to him about that particular area. We pushed this towards the end where we bought 6-4 from lift-off on the no COMM case, instead of blowing the mission at the end of 1 year. In all the history of this business, I've never had a good clear feeling on how far I can go without COMM. At least we had that feeling from the first day, and that was a comfort. The checklists are on us, Deke. I think we were pretty well aware of what was done with that. It would take us 2 days to discuss checklists, if we do that at all.

CUNNINGHAM I think it is only significant to add that we made some small modifications on the procedures that I thought were ironed out completely. I would like to pass those modifications on individually to the following crews.

SCHIRRA That's why we fly them.

EISELE This is where we really pass it on to the next crew.

SLAYTON I'm sure that everybody is pretty well agreed (as far as I know) that we want these things broken up by mission phases.

CUNNINGHAM This is the thing that is a departure from what we did.

10.0 MISSION CONTROL

SCHIRRA — I'd like to go on record saying MCC was exquisite. Really, they get down to the real big issues, and that's my whole point. The real big issue is that the mission was flawless from both sides.

CUNNINGHAM — Yes.

SCHIRRA — I'll never forget the first time I started working with them. We had some blue streaks, and they were pretty bad, but we smoothed them off. Part of what we are trying to get at is that we knew what we were doing in that spacecraft, and I think they knew we knew. But there was some old inflexibility we had from the old days. If it's in writing, that's the way it's got to be, and that's not right. We were up there flying for 10 days and not for 3 revs or 15 minutes. We had time to learn something, think about it, and assess it; and we had time to think ahead of the flight plan. Donn, we mentioned just a minute ago that you actually stayed a rev or two ahead of the flight plan by aligning before we got up so that we were always up. That's why we could take

umbrage with some of these things and why we legitimately thought we were going to have an audience on it. We couldn't wait to debrief after the event; we wanted to get it done before the event. The real big things where we really could get hurt were the burns, insertion, rendezvous, and reentry. These were really critical and were handled exquisitely. The way they set us up for that rendezvous, I just can't believe that it could have been done any better. In fact, if they had done worse, we probably would have blown it. There is no way that you can find fault with the way that thing was controlled. That means that we got little insignificant stuff like taking away 5 pounds of fuel when it should have been 1 pound of fuel. This is academic when we probably left 150 pounds of fuel in that thing. The way I see it, we probably left about 400 pounds.

REP That's right.

EISELE I expect we did at least that. Okay.

10.1 GO/NO-GO's

SCHIRRA — GO/NO-GO's are all appropriately delivered; we did discuss that a little bit earlier. - - Overlapping on GO/NO-GO's: there were cases where we weren't covered on the next area, the planned recovery points or the alternate ones and the updates. For example, if we had a GO/NO-GO for another day with six revs block update but it was between that point and a real GO/NO-GO, we didn't really know what to do.

CUNNINGHAM — I'd suggest that in the future there always be a place called in the flight plan like GO/NO-GO for 77-1. Right there, you can just list a block.

10.2 PTP and ATP Updates

CUNNINGHAM — So you GO/NO-GO for 1711, updates follow, and you get the same thing that we had for our block update.

SCHIRRA — That's your final clearance with the ground.

CUNNINGHAM — They may be reluctant to project that far ahead. There was no reluctance for letting us go that far with no COMM. I think this

was just a little place we forgot to fill; rather we forgot to cover the gap.

EISELE — Wally and I spent some time one night talking about how we could deorbit without any block data. We had it figured out how we were going to come in anyway.

CUNNINGHAM — We had a DR, one where we would deorbit on the update map.

SCHIRRA — It kept us busy for about 4 hours when there was nothing else to do, so this way we had thought about it.

10.3 Consumables — As for consumables, what we have always said and always felt very strongly is that we wanted the ground to do the trend flights; we didn't want to do them on board. We did want to know our fuel trend plot. When we finally got straightened up, they called up the number that we wanted for our onboard chart. I think this worked out well. For example, they called the electrical power up, and we always kept wondering. Walt, do you remember whether we had a 50-amp-hour or a 40-amp-hour battery? I'm convinced now that we had a 40-amp-hour battery.

CUNNINGHAM — No, we won't know until we drain those. North America had batteries that were as good as any of the others. What we didn't do was put the energy back in them. As far as the consumables go, the ground did everything that they should have done on the oxygen electric power. They kept track of the RCS fuel because our onboard gaging wasn't worth a hoot.

EISELE — I'd like to see them take those batteries of ours and bring them up to full charge, put a load on them such as we had, and see if they can deliver.

SCHIRRA — They will discharge them and charge them, and discharge them and charge them.

CUNNINGHAM — I just wonder whether they really delivered the spec bus voltage if they were fully charged. I don't know. The most significant thing to do with those batteries after they get back is to see if they have the energy left in them which we calculated. This will verify all the planning that was done on them, all the bookkeeping that was done on them. What they do at North American is take and put a fix discharge rate on it and measure all the energy

that's going out. They say, "Yes, we did have 51 amp hours - maybe - total left in."

REP Yes, but would you have 26 volts?

CUNNINGHAM We did have when the batteries were up.

SCHIRRA I think we have a point here that we're trying to straighten out in real time. If there was a 50-amp-hour battery instead of a 40-amp-hour battery, the data they were working with was starting on the base line of 40. The batteries we've had under the gun for a long time were considered by some as a 50-amp-hour battery. Now let me make my point. I want to get across finally that whatever the amp hour was on the batteries, they were under voltage when we had CM SEP. That's what I'm concerned about; I don't want that to go unseen. That scared me; I felt I lost a computer. You start off calling it fifty and then you bookkeep it at forty which was the way battery C was booked. I was shocked to see that command module undervoltage when we had separation; that's my point. That load is predictable; it's known that you can run a command module there. The batteries are under the gun. That's the whole subject.

Whether the technique is bookkeeping or anything else, unloading the batteries must be done.

EISELE — It's probably the most serious thing that happened in the flight, when you get right down to it.

SCHIRRA — That really shook me. Now let's go to RCS fuel. I assume we're talking first about SM RCS fuel. I said somewhere along the line that when I buy the SPS, it means we use a hybrid to get home on if it doesn't work. I don't know whether it will happen in real time or not, but I was trying to conserve fuel if we had something to do with it. I don't want to just blow it away for the fun of blowing fuel. But Deke left me with the feeling that the ground was going to try to preserve an SM RCS deorbit right down to the end of the mission, or at least a DAP SM RCS ... at the end of the mission. That's where we ended up. That wasn't my intention. I did realize that that was the way it was going; that's why I was sort of ginchy about blowing 40 pounds of fuel in a day on a silly experiment that we

knew better than to perform. We should get 3 or 4 pounds of fuel to arc around ourselves on our own time when we're a couple of a hundred pounds above the hybrid. Do you see what I'm trying to get at? It was poor; somehow we lost our communications in real time. When we first talked about hybrid, I wanted something that would back up the SPS. I didn't know what it was. It was a pig in the poke, and there was very little data on it. We had only 10 or 11 flight hours on any command module up until that point, and we didn't know how it would last through eight revs, but the hybrid was there to protect us if it deteriorated over 10.8 days.

CUNNINGHAM The SPS gaging is intolerably poor.

SCHIRRA That's the worst thing I can imagine. The gaging is so poor that you can't even keep track on board. You've got to have the ground keep track. That's not the way to have a spacecraft. We've always said that onboard instrumentation in prime, and I kept asking Walt whether we knew anything about this, and Walt

finally convinced me after we saw the gages change that they were worthless.

CUNNINGHAM The quality readings were grossly in error compared to the numbers we got from the ground.

SCHIRRA Even the deltas we got off were ...

CUNNINGHAM I'd like not to carry the correction curves for the RCS because we carried the correction curves, and the best accuracy we got out of it was 11 percent towards the end.

SCHIRRA That's a lousy feeling, Deke; I don't think you'd ever want to fly an airplane and have somebody tell you the fuel status.

CUNNINGHAM I think it's interesting to note though, Wally, that the service module RCS fuel was the only thing that we really were concerned about. On everything else, we either had a good reading, or we didn't care. Hydrogen and oxygen you could sit there and read, and you could read deltas. The SPS gaging system didn't work very well either, but we weren't too much concerned because if you noticed, you got so many seconds of burn time on it. You shouldn't leave the impression that it wasn't working. It doesn't update for short burns.

SCHIRRA The only thing that got to it was that they didn't want to lose sight of it. In Gemini, we all felt content. I didn't have it in Gemini VI, but I knew all about it because we helped work it up. The Volkswagen tank concept: here we had the secondary propellant, and we just went in on some unknown number that ground had ginned up. I'm sure it was a good number; I'm not trying to criticize the ground, but we didn't know what we were doing. We had no assurance that we were going into the secondary legitimately other than from ground data. The name Volkswagen comes up because when you run out of fuel in one, then you switch over.

CUNNINGHAM A good way of testing that kind of thing, if we can get the test run, is to let the lines run dry. The thing we couldn't do was switch before the lines below the tanks were dry. I don't think it would hurt to have a few tests run where you flip the engines out by running those lines dry, pressurize the secondaries, turn the secondaries on the line, and see if there's any problem filling those lines back.

You could run the tank until you were getting no more fuel out of that quad and then switch over, and you have a true Volkswagen.

SCHIRRA There's supposed to be more Volkswagening down the road. The SPS fuel thing was very academic, and I guess all of our prep time, trajectory, and everything else, was academic. Some guy thought he was the most important man in ASPO. He had to get his pugs test done with the result of changing trajectories every time somebody sneezed. Right until launch date, I didn't really know for sure what kind of mode we were going to have in that darn SPS.

EISELE Those burn times and schedules changed weekly; in fact, they changed in flight even. The whole business was keyed to this pugs test which had to be done when the fuel in the tank was down to a certain level in order to uncover the sensors.

CUNNINGHAM It turns out that the burn we did make was longer than any we've ever made.

SCHIRRA I'm afraid that that kind of thing gets highlighted to the point that the guy's objectives seem like the only thing that's going on.

That's what was getting to us on some of these occasions. It's like anything else; you've got to stand in line. If the system isn't working too well for you, then let's get out of there.

10.4 Flight Plan Changes

I think flight plan changes are pretty fully documented; there is no sense hammering on that except to stress one point. If something comes up that's a departure from the flight plan, it's just a "gee whiz" change to make something better; it should be exercized and simulated on the ground before it's sent up, first to trim it down and make it come out right. You said earlier not to mess with the computer unless you've done it once before.

EISELE Most of the flight changes we got were detailed things; for instance, the real time calling up of the fuel cell purges. Those were times when they expected an update for this event, also maneuvers and changing times to power up the computer, for instance - just little detailed things, and I thought it worked very smoothly. I used to get a lot of those flight

plan updates on my watch. It was kind of interesting; you could pencil those in and look at your next day's schedule and then kind of put it all together.

SLAYTON Those are updated times, and the basic plan was nearly identical to the flight. There was one day that we had to put some ETO's in there.

SCHIRRA The only thing that did disappoint me was that we discovered our phenomena, the perigee torquing problem, and I gave them 48 hours notice to do something about it - it's in the log - and they didn't pay any attention to it.

EISELE We had a couple of days that were rescheduled; I think it was around the third or fourth day when we were getting pretty bushed. We took it easy for one day, and the effect was that we lost a day or part of a day of landmark tracking which they subsequently sandwiched in later in the flight. I thought it all worked out very well. We still got our six good passes for landmarks. ...

SCHIRRA We had a lot of time to regroup because we had someone on watch all the time. That guy could

go ahead a little bit - which is what we all did on our quiet watches - and block out the next day. That's where we discovered that we ought to do a 51 about a rev or two earlier then we had planned doing it.

EISELE Yes, I could see -

SCHIRRA - which helped us, Donn. You can really get in trouble on retro. The day we came down, I'd say we had about 5 minutes gravy there; and if we hadn't really made up just right, we would have gone another rev. Donn had already set us up about a rev early.

EISELE One thing that enabled you to do that was that you could tell from the hydrogen usage early in flight that it appeared we were not hurting for consumables. I didn't mind at all about powering up an hour or so early once in a while to get started.

SCHIRRA There is something we discussed which we haven't really talked about yet, and it's appropriate to catch it now. There's no reason why you can't bring the computer up for about 4 or 5 minutes and get something out of it and put

it back down again, and the other crews ought to hear that.

EISELE We did that a lot.

SCHIRRA I know we did later. At first, we were very reluctant to do it, if you remember. That's just a decimal of the whole period of time you are powered down. It doesn't eat into your consumables, and it's a very easy procedure to just bring it up, get the information you want out of it, and plop it back down.

EISELE I got a map update a couple of times that way. On one of these long pamphlets where it wouldn't go over a station, I'd want to update my map. At that time, I called up the computer and let it integrate forward in P00; I then called up program 21 and got a fix out of it.

SCHIRRA I'm glad you said that, by the way. That's the other one that's fairly late in the game. That was the funny looking thing that came up late; it was integrating forward in P00, and it took about 4 seconds per hour.

EISELE No, about a minute per hour.

SCHIRRA Yes, that's right, a minute per hour - 40 seconds per hour ... 20 seconds per state vector,

and the computer would integrate forward. If you shut it down when it was not in P00 and then brought all this data back up to speed again, it took 20 seconds per hour per state vector. If you went into P00 from a dead computer, it would take 40 seconds for every hour you shut off.

EISELE Yes, for a full day, it would take you about 20 minutes to get state vectors up. In other words, the COMP light would go out, and you could use it for something. MIT came up with some Mickey Mouse procedure of VERB's and NOUN's so that you can somehow bypass that integration, and this would permit you to load in a state vector from the ground over the uplink. Rather than fool with that, we just decided that we would go ahead and call it up deliberately every few hours and let it integrate forward so that we were never more than 5 or 6 minutes from having a usable computer. I think, if any of the other flights do intend to power down for extensive periods that they ought to consider doing things like that.

10.4 Flight Plan Changes

10.5 Real Time Scheduling

SCHIRRA I'd say for the first day or so, unless they are really going to try to make a point out of it, let the flight plan live as it is unless it is a safety device. That kicked us off the wrong way. There is no way to judge how well that crew is falling into the mission. The one guy that can judge, I feel, is the crew commander. We are all trained to sound casual even though we are just about coming apart at the seams. That's the way a pilot is. He knows he has had it; that's the way we've disciplined ourselves. I think you're best prepared on board to determine how well you're able to pick up new ideas or changes. We've got to have people respect that. I may have goofed by resisting it. You just don't know. What are you going to do? All of a sudden, you realize you can cut it. You don't know that before you get there, but no one else does either. I don't think you can judge us from the ground on how well we're doing. We were pushing hard at first. About the fifth or sixth day - we

talked about this earlier - we could take these changes and swing with them, but not in the beginning. We adjusted to the environment immediately. I think we all liked that. Do you fellows have anything to say on the subject?

EISELE I never really felt uncomfortable about the real time schedule.

SCHIRRA Then you weren't aware of the problems?

11.0 TRAINING

CUNNINGHAM — Under training is a whole new section.

11.1 CMS

One of the things I said right from the beginning was "Thank God we've got a CMS." But watch your step as we go down the stream because it has been around waiting for the crew to come back for a year. I don't know how you are doing, but I assume that -

MISELE — I understand next week they are coming up for 104 on our simulator.

SCHIRRA — Yes. Those guys are doing a great job. I would like to make it clear, once and for all, that it is never 100 percent. That's never ever. The EMS never worked. If we had to work with the EMS in the spacecraft, I would have had go to back to Houston and get my EMS training.

CUNNINGHAM — Here is a very important point. Of the tasks that occupied me during the flight on the right side, almost none of them were on the simulator.

SCHIRRA — Our COMM never worked as a COMM system. I told you that very late in the game. We blew

some runs with Houston on COMM; we just couldn't talk. We blew that run we had with real test conductors and our pad leader. Then we couldn't talk. We tried to do a last minute insertion with them.

CUNNINGHAM — The CMS is not a 100 percent representation of the real spacecraft, but it is pretty darn close. I still think that an hour in the simulator is worth 10 hours of bocklearning and -

SCHIRRA — In contrast, simulator time is worth a hell of a lot more than spacecraft time - free flight.

CUNNINGHAM — Yes.

SCHIRRA — I would say that it's probably on the basis of about 1 hour in the simulator being worth about 10 in the spacecraft.

EISELE — That is if the simulator is working. Actually, we did have pretty good luck.

CUNNINGHAM — I would like to add another opinion to this. I realize I was running down a slightly different path than you guys were on these systems because the simulator has a heck of a lot more benefit for trajectory and flying type things than simulations. Towards the end, during the last several weeks, I wasn't getting in

the simulator too much, but I was getting more out of reviewing things that were paper work.

SCHIRRA You were reviewing test data, too. More data was coming in.

CUNNINGHAM That's right. I was also looking at the malfunction procedures. I feel that I could operate the malfunction procedures, not just read it and then throw the switches. I feel very strongly about being able to be involved in the procedures development on those systems malfunctions.

SCHIRRA I think what Walt is trying to say is that the simulator let him down on systems training. It was way up on G&N training, SCS training, -

CUNNINGHAM Yes it was. It was way up. It was excellent for some of those things.

SCHIRRA As it turned out, it was even to the point that he and Mr. Bonhouse over there were like the real one. That still bugs me.

REP We had two big blocks of systems malfunctions that we never did get in that one. We are probably not even going to get them in for 103. Many of these are based on your recommendations. It just takes time to get them in.

CUNNINGHAM I understand. I never expected them to get in for us. I was thinking about downstream when I recommended them.

SCHIRRA Well, don't misunderstand. We are trying to say that we never say all the good things.

EISELE I had a good time in it. Some of the best time I got out of the simulator showed when I was doing alignments.

SCHIRRA Let's make that point. We have said this to everybody, but I don't know if we ever recorded it. Simulator optics, but for the shaky star ball, is exactly like the world.

CUNNINGHAM Yes, it sure is.

EISELE If you can get out of the black hole through that telescope and find your way around, you have it made. We might suggest a little extra practice around Acamar and Achernar.

11.1 CMS

CUNNINGHAM — Before we left the CMS, we should have mentioned the fact that all three of us benefitted by our block I CMS training. I felt like I was a lot further up when we started than we were at the beginning.

SCHIRRA — I don't think you should lose sight of the fact that we had quite a lot of time on block I. It didn't show on our total bookkeeping. We felt we were ready. I think everybody else knew we were.

CUNNINGHAM — Numbers don't mean a darn thing.

SCHIRRA — LM crews are going to be in the LM. Pete Conrad told me he had something like 250 hours in the LM and less than 100 in the CMS. That is the exact answer I was searching for. He doesn't care about the CMS as much. That's the way they go. We are seeing that. I told Donn that the rendezvous was your baby all through the braking. Donn worked the thing out and spent many hours with that device in Houston and many hours down here. He even ran that thing for the last week or so. We are trying to prove that it is a one-man job, which it is supposed to be.

FISELE With Colossus, it almost is if you just use it that way. Don't do anything else.

CUNNINGHAM Yes, don't do any backup.

SCHIRRA That brings in the CMPS.

11.2 The DCPS

The DCPS was a damned good machine, and I don't think you have to log hours on machines like the DCPS. If you can get good hifidelity training, you only need 1 hour of it. I keep using the example of that big balloon that Harold Johnson made for my Mercury flight. Remember, we went over and looked at it? That was enough. DCT is by no means that simple to learn. Marshall was pushing for this darn angle-of-attack case, the max Q abort with the two engine out abort. Mike Wash and Dick Warren said to send them up the sample problem we were talking about with the entry board. We did it, but they could not conjure one up. It turned out that those people were just blowing smoke. They were worried, and they finally got down to trying to create a set of equations that would duplicate the problem. They couldn't get it within realism, so all that academic discussion was washed away. Maybe you know that. I think that is a real example of what a device like the DCPS can do as a lever to knock out this trivia.

11.3 CMPS

We used it for EMS training. We probably would have used it a lot more if we didn't have the CMS. It was used independently of crews to evaluate the EMS. That was one of the few simulators where I was taught how to do something. I was taught how to use the EMS on the CMPS.

EISELE I would just like to make a general comment. I think the amount that you use simulators other than the CMS depends on how much time you have. If you are tight (like I think we are going to be from here on in), these Apollo mission crews aren't going to have time for what I would consider auxiliary trainers. You do need some DCPS time if you are riding the left seat on launch because that is the only way you can learn the launch procedures and really get them pinned down. The CMS is limited in that it doesn't have very many resets or IC's for these various conditions. The same thing is true on rendezvous. The big advantage of the CMPS for rendezvous training was that you could get a complete spectrum of

[redacted]

initial conditions, errors, and so forth to plot and work with. You can't always do that in the CMS; it's not that flexible.

CUNNINGHAM — It is also a place I can go and work by myself on the backup charts.

EISELE — As far as I am concerned, the heart of the whole training is that Command Module Simulator and the CMS.

SCHIRRA — Here is a point we discovered toward the end. I benefitted more from the CMS for launch abort cases after staging.

EISELE — Yes. I used the DCPS for everything up to and including staging. I wouldn't use the DCPS for mode 2, 3, or 4 aborts. That was done with Houston and with the three-man crew here in the CMS. I think that might help the guys that have to go roaring back to Houston for DCPS.

CUNNINGHAM — The LMP needs a very brief familiarization on the DCPS. I don't think I have 4 to 6 hours with you in the DCPS. Anything that I have to do on aborts is more associated with what the CMS can give you.

[redacted]

11.4 North American Evaluator

SCHIRRA I wanted all our burns validated because at first we weren't getting sextant star validation. Back in block I days, we had 1 week to go before we got our final burn validation. Finally, the CMS started coming in. We had the evaluator available to cover us for a long time. I think it is still appropriate that when you make a change in a program like Colossus that you check it on the evaluator that has three little interface problems; then you finally live with the CMS. I don't think you will disagree with that.

11.4 NR Evaluator

EISELE I was going to make a remark about that evaluator, to the effect that it is a good thing to take part in if you happen to be at Downey, but I think that future Apollo flight crews they should not make a special effort to go out and take part in the North American evaluation. It is nice to know that they are doing it. I think that the evaluator should be kept up out there to validate computer changes and even procedural matters and hardware problems as they come up, but I don't think that as a training device, it would be as useful at this point in time as it was a couple of years ago when we were just starting out.

SCHIRRA You reminded me of something while you were talking about that, Donn; it is very significant. I was in a conversation with Pete Conrad the other day, and he and someone had to pack up and go all the way out to San Francisco just to look at some models of the dome of the S-IVB. They were looking at our movies in here and said, "My gosh, why did we mess around with that? All they have is black and white television." They

went out to San Francisco to see something when, in fact, that's the kind of stuff you want to call up at DTO. We tried to take pictures of the S-IVB in all different attitudes so the sun would hit, knowing that it was going to be a problem to pluck the LM out of there. That's the kind of stuff you want data one. When you get into that kind of simulation or angle simulation for lunar landings, we should hope to get something from the next mission. That's the way the DTO should go. If you can worry about lighting, let's go ahead and work for that. We intuitively knew that was a problem so we tried to get lighting all the way around. I think the way out simulation, if I can call it that: leave the crew that is assigned off that; let somebody else do it; see if it's worth it. We had a lot of time at the plant because we were watching the spacecraft come back together again. We went through change periods so we could look at this evaluator.

11.5 Egress Training

SCHIRRA The Cape was running awfully scared when we first came down here, and we had an overkill on

egress training such that we started off with rather bad relations with the Cape. On the chamber run, they had us booked up for about 2 hours of dry run egress training with the real spacecraft in the chamber; on top of that, they wanted to lay on about 12 hours of altitude chamber, and that was a big mistake. They have learned a lesson, and we have too. I guess in a way, it is fortunate that we got it over and done with because we all grew up again. You know, you don't cover your numbers by putting the crew through their paces, and that's what they were doing. I think we have that pretty well straightened out now. You have to see all the different motives. We did that, and I think we were well prepared for any mode of egress from that spacecraft. They resisted us on very few things. I think Rocko's crew really turned around backwards to get things in there. The launch complex down there was exactly the way we wanted it when we left. We had the chemical fire extinguishers up there that we wanted. Wiring that was in the way when we were up there; that was out of the way. The egress training we

have down here in our training building was a real stroke of fortune; that helped us a lot. That was used.

EISELE In general, I'd say that you could knock off the shirt-sleeve dry-run egress training exercises; they don't prove a thing.

SCHIRRA Yes, the people down here didn't realize that we knew what the entry interior was like.

EISELE That's a good point.

SCHIRRA One point on which we differed from our backup crew was in worrying about our suits maintaining their condition, and that point hasn't come up yet. The suits, in fact, haven't even come up in the debriefing. There were a limited number of cycles on the zippers on the suits. At the very end, Donn's suit was facing a zipper change, and we left it the way it was. The leak rate was marginal. It hadn't gone yet, but I think the zipper was about ready to be changed out. We bit the bullet on that and went with it because we didn't have anything to do with the suit to speak of. If we had had a hard cabin, I'm sure Donn would have had a little bit bigger lump in his throat than he had.

EISELE — Yes, it was a leak slightly over spec or something, but it really wasn't a bad leak.

SCHIRRA — The reason that I bring this up is that you don't want to abuse your suit practicing egress, but you better do it with a prime or backup suit, not a training suit. We used our backup suits on the slideware, and they are and were very different from the training suits by bulk and stiffness or whatever.

CUNNINGHAM — I'd like to add one thing on this egress training. You're talking about pad and water. We had been through the water training in the tank and in the Gulf or spacecraft 14 and in spacecraft 101, and I feel that as a direct result of that, there was absolutely no consternation or concern or anything when we ended up in stable II.

SCHIRRA — That's right. I think the world was worried about it, but we were not.

EISELE — In fact, it is surprising, and it's hard for anybody to believe, but there was no concern. It was just — well, I'll be damned; here we are again.

SCHIRRA The only thing was getting sick.

EISELE But even that was practiced; I got out my barf bag just like I always do, and everything was normal.

CUNNINGHAM I guess the main point is that I want to put a pat on the back for those guys. There may be some mild shortcomings in some of that training, or maybe we neglected a couple of things because of earlier seasick episodes, but the training was just damned good.

SCHIRRA I've got a real big point I'd like to bring up, and that's right; it was that good. One of the big flaws — and I brought this up to the doctor, I told Bill Karpendea about it, and they understand this and I think it's just going to have to be a requirement: any time you do water egress training in the Gulf in the future, schedule in a flight surgeon like Bill Karpendea (who was there when we got in the chopper after the mission) to go down with the crew to the retriever. When the choppers come by to pick them up out of the water — the chopper comes by the retriever to pick up their clothes, and then it goes over to pick

up the crew — the chopper should come by and pick up the flight surgeon, and he should be in there just like he's on recovery bay. They go and pick up the crew and the guy sees a whole evolution. The reason I said it is because we were really pooped in no time at all, and that's the same way we were after the mission: we were pooped. The only thing that kept us up was that we were exultant about the fact that the damn 10.8 days were over at last. That's what was the variable.

SLAYTON What you're saying is that the guy that's going to be in the recovery forces should be in the egress training exercise.

SCHIRRA They were told this; they may have done it. Karpendea agreed with me completely, and it was a nice feeling to see someone you knew in that chopper, but he can see how we look if he goes through that exercise.

CUNNINGHAM Yes, he was saying that he stayed awake the whole night before figuring out how he would handle a broken arm or broken back. He was really prepared to leap in and take care of things.

SCHIRRA He was all rigged up with a wet suit, Deke, probably for the first time in years, and all sorts of stuff. They guy is very devoted, a real nice boy. One of the first ones I've seen in a long time that was really in there pushing. He saw the shortcomings of not covering the egress training. I think you just have to schedule that thing out, that's all. They've got to be there. That's one of the things I want to talk over with Chuck and make him understand this problem.

11.6 Planetarium

SCHIRRA Walt and Donn, I guess what you're saying is probably right. When you first come to bat, you're familiarized with the planetarium, but you don't train.

CUNNINGHAM You have general training, not specific mission training.

EISELE I would not waste my time going into planetarium; you'd get better results using the star ball and the simulator.

CUNNINGHAM You might leave it because we do have access to Griffin Observatory, and if there is ever a quiet time and you're in Los Angeles, it's

available. But I wouldn't try to schedule it in the training schedule.

SCHIRRA — I'd cut down the time on that planetarium on the training plan.

11.7 MIT

EISELE — I would say for assigned flight crews in general that MIT training is a waste of time and a dead loss. You get next to nothing out of going up there because their simulation is not that good. It doesn't run most of the time. If it does run, it's not very realistic. It's a part-task trainer, at best. Their training discipline, I found, was always lax and just not up to speed. They look upon it as a laboratory exercise, such as flying a bodacious rate command. I just don't think it's worthwhile going up there. There's nothing unique about their hybrid. It's nice to know that they do or can verify certain programs or procedures on it, but as far as the flying crewmen having to go up there and actually taking part in that —

SLAYTON — That falls in exactly the same category as the MU trainer at North American. They have the tool for validating programs.

EISELE — After the first course, you don't need a week at MIT is what we're saying.

SLAYTON — How about the navigator and just the briefings up there?

CUNNINGHAM — He's mentioning specifically the hardware, and I personally felt that I had about 2 days worth of benefit to be gained during our training schedule from the briefings up there.

SCHIRRA — Whereas 6 days were invested.

CUNNINGHAM — There are some things I did get from listening to them, and I think we made a lot of criticism up there aimed at cutting it down.

EISELE — I think the briefings are worthwhile, but you don't need a whole week of it. There's something unique about going up there where all the people are who actually did the coding and did the detailed writing out of all that program; you can listen to them, and you can ask questions. You don't get that anywhere else, but it doesn't take a whole week of that.

SLAYTON — Couldn't you back off and do just as well if you had somebody like Frank Hughes spoon-feed you on the CMS?

CUNNINGHAM — Frank Hughes is a good simulator man, but frankly I think Donn and Frank saved time by sitting and listening to MIT as they did in that Donn is removing one layer of filtering out of the system. Personally I felt good that Donn got up there and talked to them himself instead of getting it all from a simulator.

SCHIRRA — Than again, that was developing. We were developing the program in a sense.

EISELE — I would say 2 or 3 days at the most are all you need at MIT for an assigned flight crew. Go up there, get that time block done, learn the details, and ask the questions. From then on, you don't have to go up there anymore. If you have any questions, you call them on the phone or have one of your support team call them.

SCHIRRA — What I'm trying to point out here to Walt and Donn is that we can face that. I think in part I can provide some help in some areas. For instance, what can we cut out of this thing that isn't worth devoting a lot of time to, since we're trying to abbreviate some of this.

CUNNINGHAM I would say take the week at MIT and cut it in half; take only briefings, and don't bother with the simulators. I'll tell you one thing that you certainly don't need if it's not already cut out from the MIT briefings, and that is a briefing on the nonflight ropes, particularly the ones that are used for checking out the spacecraft. Our crew managed successfully to get around this every time we've been there, but they usually wanted a day or a day and a half to talk about the test ropes. However, we're just working in OCP, and I don't think it was necessary.

SCHIRRA I think the point is that when you finally get to flight ropes, then you can start playing hard nose about seeing things that you expect to see. Until then, just assume the test engineers know more than you do about it. If you see anomalies, ask a question and put it in the hole. If they explain it as a flight rope thing, then say "okay" and keep your ghost book going; that's the thing to do. We had ghosts and they were coming up all the time. That's a good point.

11.7 MIT

SCHIRRA — Donn, do you think it is required (and I know what your answer is going to be) to go out to the desert to look through a sextant?

EISELE — No.

SCHIRRA — Or go up on the roof to look through the sextant, or should you just do it with the CMS?

EISELE — No, I'd do it in the CMS. The one thing you can do on the roof at MIT is put a star on a lunar landmark. Having done it on the roof and having done it in orbit, I can say that it's a very simple task, and there is no need to go up there and do it.

11.8 System Briefing

CUNNINGHAM — Systems briefing, I already covered that on that. Launch vehicle, S-IVB, S-II are going to be coming up. The review at Huntsville that I think is now worthwhile going to is the one day-long review. I knew more about certain things than a lot of people in that room did, for example, the lunar landing.

EISELE — That was the one subject that all three of us went for one day.

SCHIRRA — Yes, we covered it the whole day. That is the one briefing in which the crew should devote a day and leave them clear; that is all they should need.

SLAYTON — What about the spacecraft DCR? Would you say the same thing about that?

SCHIRRA — We're better prepared than anybody else down here to hit the spacecraft. I don't think it necessary that we should go to Downey for these big NASA reviews.

EISELE — Again, it's a question of priority and how much time you have.

CUNNINGHAM — That's right.

EISELE — I would say the DCR, particularly the ones at Downey, are probably pretty far down on the priority list.

SCHIRRA — Yes, you should know what you spacecraft is like by that time.

CUNNINGHAM — You've got to keep in mind that the crews coming along are not going to know it like we did, or how the spacecraft is at that time. I'm saying that my feeling would hold only if you felt very seriously on certain specific items.

SCHIRRA — I hope that isn't true, Walt; I hope that somewhere in their team someone does know; like Al Warden knows how that command module is going for that crew, and Fred Hayes knew how a LM was doing because he lived with it. So the crew that's assigned to it individually, that's going to fly it may not, but they had representation. Those are the guys that go to the DCR's.

CUNNINGHAM — I agree on that.

SCHIRRA — That's what I'm trying to get at. I'm not saying to ignore the DCR's. I think one thing we can say on the spacecraft systems briefing is that the North American systems briefings were the best we can get. They're getting updated. I'm

not sure how good they are now, but they were being left out of loop as time went on. I suspect North American cut back in that area. They were always tempted to cut back in those auxillary efforts because they're cutting back. The same point: the simulator kids are coming along pretty well. In Houston, particularly, they didn't come on too well here. There may be a way of looking at something we don't know enough about to discuss, but I'm predicting that North American's systems briefing experts are going to start being cut off the vine.

CUNNINGHAM Well, there a shortage in both ends there. I feel as if they complement each other. The North American systems people know nit picking engineering details, but a lot of them also feed a company line, I think. On the other hand, I feel like the simulator people can tie in the operations, but they often don't know all the details. I guess I'm not that strong a fan of getting all my briefings from the simulator people at all.

SCHIRRA No, but I'm saying the world has changed rapidly since we've flown.

CUNNINGHAM I find I have to answer simulator people's questions more often than they answer my questions on systems.

SCHIRRA Yes, we've go to move ahead. I do believe that North American's personnel are going to be cut back.

CUNNINGHAM Well, they probably will.

SLAYTON We always get whatever we need from them.

EISELE The point is do you need a healthy major of systems briefings, particularly if this is your first go at a command module? Crews recycle; or whatever happens, maybe you can cut back on some of those. But I found that our sessions briefings were invaluable. We learned a tremendous amount during those periods. The subject is people that consult for special areas, and I'd like to register the fact that Bob Shane who works on the North American evaluator is probably the best one-man source of G&N information that you'll find any place because he either knows the answer right off, of if he doesn't, he can find it within an hour or so by digging through his data. I would just like to register that if any crews have any questions as long as Bob

is out there in that capacity — now, of course, unless he gets transferred —

CUNNINGHAM Part of the problem is that when people move up, they're not in that capacity any more.

EISELE I'm sort of handing him a bouquet of roses.

CUNNINGHAM He gets promoted out of there.

SCHIRRA Interestingly enough, though, I notice what he's saying. He's not talking about anybody here with simulators or anybody in Houston or anybody at MIT; here's a guy with North American who has nothing to do with the damn thing like putting it in the spacecraft.

CUNNINGHAM Yes, and I'd say the same thing on the systems. There are a couple of systems here like fuel cells ECS, DPS that when I really wanted information, I called North American or our FOD guys.

11.9 Experiments

SCHIRRA We had a lot of time for a limited number of experiments. We did talk S005 and S006, that target of opportunity. It's always going to be, and I don't think we need to devote all that time to it. Initially, I asked for one man to come down here with a capsule digest, and a whole batch of people came down. It was nice

to socialize, and we discussed all that stuff. But it ate us up; it took too much time. Clouds are clouds, and we know what they are.

CUNNINGHAM Training equipment not really very applicable; we all have Hasselblads and shot them with 16mm film. I will say I did get something out of shooting the pictures that I did. I got a lot out of shooting the pictures I did.

SCHIRRA I think, Deke, that the way to get guys to play with this Hasselblads in training is the real point. They are cutting back on budgets. You've got to give the guy the fun of realizing that he's going to get a picture back from it. Then he'll play with it some more.

CUNNINGHAM I don't know how you're going to feed that because I tried religiously for a long time to take at least a roll a week on the weekends, and there was nothing slightly akin to the feeling I felt after I took the pictures in flight.

SCHIRRA No, but your attention is brought to the camera if you can shoot a picture and expect to get it back, if it's your kids or your new car or

or broken pipe in the house. You anticipate seeing that picture come back. And that's the reward for playing with the camera.

CUNNINGHAM Incidently, Dick Thompson down there did a nice job, I felt, on looking at each slide and critiquing each exposure, and I got something out of it. All you really have to do is keep that loop tight so that they get a priority; they get developed, and they get the feedback right away before you've taken a couple of other rolls of pictures and lose sight of it. What we really ought to push is everybody should be taking pictures with their light meter, as far as I'm concerned.

SCHIRRA What we should push is to get more light in the CMS. We know what the numbers were in flight now. The lowest we got were sixes and sevens in that spot meter. Get that light level in the CMS and shoot some IVA movie in there, if we need to. Even that's not a requirement anymore.

CUNNINGHAM On the movie camera, be familiar with the controls and be able to get it out. I'm hoping that the controls from the new camera - the new 16mm camera - are better than the ones that I had. I think, and I haven't logged this any place else, but when that camera was mounted in the window, I couldn't really see the index for the

f stops, and I scratched another arbitrary index halfway around it and scratched some more marks around the lense for the f stops. I would hope that the new camera has that in clear position to see when it's mounted.

SCHIRRA Okay. Let's make a capsule digest for future flights. The movie camera is only usable for photographing another object nearby. I don't think I would waste my time taking movies of the moon.

CUNNINGHAM I agree with you, with your conclusion. It's just not that good a piece of equipment.

SCHIRRA You really need a bigger lens, and you can't afford to have that 35mm movie camera.

11.10 Spacecraft Systems test

SCHIRRA On the spacecraft systems tests: at Downey, the philosphy was very good. They were a little worried about this; they had dry runs. They wanted the spacecraft to look good before we played with it. We had good support from the ATO research pilots. When we got to the Cape, they were not prepared to test the spacecraft well. They had a long, long arduous learning period, and they goofed many times. The

reason for this is that they were completely and totally dependent upon the OCP because they never rehearsed. They sat down and worked paper, and that's what the Cape's problem is. They work paper; they don't work equipment. As a result, if the equipment doesn't follow the paper, they are completely bogged down. I think that's the difference between Downey and the Cape.

CUNNINGHAM We did learn something here, too, as we tended to back off in participation in the OCP from what we had at one time thought we wanted to. I'm talking about prime crew or backup crew participation. I think that's very appropriate. The support crew did take part in some other tests which is appropriate also, but I think there is a tendency on the support crew to want to get the inside time, and there may be more emphasis than is necessary even on their part in some of those tests. But when the crew starts pulling out on some of those tests, we've got to have enought support from guys like the ATO pilots out at North American.

SCHIRRA We've got it.

CUNNINGHAM — I think they're spread kind of thin right now. For instance, when they came down here, they had two people to cover 24-hour shifts.

SCHIRRA — Yes, but we've had only two people down here for some of these combined systems test.

EISELE — I don't know that you need that much coverage.

CUNNINGHAM — I guess I'm saying that when we're not there I like to have those guys with their nose on those critical tests.

SCHIRRA — I think the world has learned more about what to look for. You have to do that the first time around, but you don't need - in airplane words, you can use crew chiefs: you don't need a pilot in there to test the aircraft every time you test it because you know more about the aircraft. I think we know more about the command module now, and we can back off -

CUNNINGHAM — I agree. But the guy observing the test out there - you can have a critical anomaly not be noticed from the fact that you've got a COM TECH sitting there instead of a better qualified person.

SCHIRRA — You're thinking back; I'm trying to think ahead. That's the difference. You're right. In those

days, you had to have somebody.

CUNNINGHAM An anomaly can come up and be discovered earlier by a more informed person. While I think the crews should be pulling out from some of those, I don't think we ought to change the intent of that memo that the ATO pilots still participate. I'm not asking them to go participate in more tests.

EISELE True; I agree. I think we can keep essentially the same ground rules that you have right now, and maybe make a little more use of the ATO's.

SCHIRRA The real point that I'm trying to get across is that the Cape has got to practice these OCP's more because they're changing all along. New equipment is coming down there, and we're moving faster. We had one session which paid off, and Skip thanked me for it. Skip went down to the simulator with us one day, and they got on the panel; and we went through another ingress together, and Skip said it really helped.

CUNNINGHAM Prelaunch count, and we actually found things -

SCHIRRA That was not a scheduled exercise. That was one we just copied. Both at Downey and the

Cape too many components were running inordinately long during testing periods. Fans, cabin fans, suit fans, integral lighting, floodlighting, inverters, IMU, moving components that were just plain way out in the curb.

CUNNINGHAM — Inverters - I don't know, lots and lots of hours on inverters. If you ended up holding and going to a trouble shooting routine, they were always on for long periods of paper work and x number of hours for troubleshooting.

SCHIRRA — I made this plea at the FRR, and I just ask again that it be followed up: that somebody learn how to power down when there's a discussion going on, and we could power the spacecraft down. We had the drifting flight; we were powered down in about 2 minutes. We didn't have to route OCP for that. We followed the normal checklist, but it was a rapid power down. We were conserving the very same things we were talking about. That's how we stretched the flight. That's what Dave has to learn how to do. Trust the fact that the damn test connectors know how to power down, and we'll put the BMAGS in warm up; even that will help.

Get the ID off the line, keep the heaters on, and this kind of stuff, and I think we can end up with even more highly reliable spacecraft than we have, which is very reliable.

11.11 Launch Simulations

11.12 Reentry Simulations

11.13 Sim Net Sim

SCHIRRA Launch sims, reentry sims, and sim net sims were all discussed very thoroughly, and they're the best part of the whole training program. That's when the CMS does become a mission simulator by name. Up until then, it's a part task trainer. I've said that for years, and if you recall, I came to you, Deke; I was a little worried about 180 hours, and I think we as a crew probably got a good 100 hours out of that.

SLAYTON Excellent. You got more than that.

SCHIRRA Yes, and it's the best thing that ever happened. That was really good.

SLAYTON No doubt about it. I think my feeling about this is that you essentially have to be fully trained when you get to here.

SCHIRRA You have to be, or you can't move with it.

That's right. But then you really integrate. That's what I was trying to say in answer to your and Riley's suggestion that the three of us get together. That's when the three of us got together.

SLAYTON Yes.

SCHIRRA I think you're going to find that it's even more appropriate, because your two LM guys are going to be off in the LMS and your CMS guys are going to be in the CMS. You're going to be forced together on these simulations, and that's the time to bring them together. That's fine.

11.14 Mockups

SCHIRRA I think we finially talked North American into what a mockup is for, and we learned a lot from it. We solved lots of problems with that mockup down here, and we saw lots of problems that North American made. You also have to have a full scale high fidelity mockup. When you make a change, you've got to see it from three dimensions. I guess the best example of that is that the GSE hatch counterbalance did not fit the real spacecraft. If they had

done that properly in mockup, we would have discovered it there. As it was, we threw it away; that whole piece of hardware was thrown away because it wouldn't work.

EISELE Yes, I think as far as training value rather than put a fixed number of hours - you could do that for planning, but mockup is something that you like to have available as things come up that you need to ring out or check in there. Just like we found out: we rehearsed in great detail our suiting and unstowing routine, and then at the other end of the flight the stowing and suiting up again for entry.

SCHIRRA I don't know if you realize it but when we're in real time - In the simulator over here, both the mockup and the CMS, you can go through your time line to where we had things stowed, the gloves, the helmets, the suits, all of that. That helped us a lot; there were no surprises on that. The one thing I do recall when we gave up that mockup here because of the urgency, was that a lot of new things came down here all of a sudden that we needed to mockup, and we didn't have any place to do it but the real

spacecraft. That's kind of awkward to go all the way down there to get your badges, put your little white suit on, climb up there, slip in there, and get inside time. We did, but the mockup would have been the thing to solve it for us. The mockup followed behind us right at the end, way behind. I'm talking about the hatch urine dump, waste water management change, the foot pan change that implemented unfortunately right in the command module because we have a high fidelity couch in there in the CMS. The mockups were falling way behind us toward the end there.

11.16 Sextant training equipment

SCHIRRA — On thing I would like to get on record here: I understand that you are finially going to do it; they are going to have a camera on the sextant.

CUNNINGHAM — Great.

SCHIRRA — Remember I asked for that up at MIT 3 years ago? Last year, they finially moved out and got one. We were really crying up there for something like that.

11.17 Planning of Training

CUNNINGHAM I'd like to make a negative comment on planning and training. A lot of effort was put into trying to get us to go use the water tank for example for IVA.

SCHIRRA It was turned off?

CUNNINGHAM Yes, and I think appropriately so. I just think for the future crews coming on, they should have no concern at all about IVA.

SCHIRRA What we're getting at - we have zero g airplanes? Forget it.

CUNNINGHAM Right.

EISELE Right.

SCHIRRA Water tank, forget it. If somebody from the old EVA club thinks that water tanks are great, have him go play water tanks for EVA, but don't waste your time on IVA. We're here to say that IVA is no problem at all. We gave it every effort we could.

EISELE There is no requirement for zero g aircraft or underwater training for IVA. I would say that includes going from the command module into the LM. It is going to be so easy in a shirt sleeve

or suitcase if you have a reasonable cabin. It is a waste of time.

CUNNINGHAM Absolutely correct.

EISELE I don't understand what the problems are with EVA.

SCHIRRA The suit, the suit is the basic problem.

CUNNINGHAM That's a problem.

EISELE If you have enough handholds, I think you should be in good shape for it. Incidentally, handholds do not have to be battleship type handholds.

SCHIRRA That's right.

EISELE You mentioned about going from the command module, to the LM. I know they are going to comment on the fact that you have to clear the docking tunnel. I don't think that's going to be a problem, either.

SCHIRRA It can't be any worse than our putting a lid on that lithium hydroxide stowage box where I practically pushed the couch through the overhead.

EISELE You are going to be able to do it just fine as long as you have a handle so you can apply

the torque to unlock it, and as long as it will meet all the interfaces for stowage or what you're going to do with it when you remove it. I guess I'm saying that I don't think you need any zero g training on that either.

SCHIRRA What we're saying is that all IVA is so easy that there's no sense doing - underwater or zero g training.

SLAYTON We have a lot of EVA.

SCHIRRA EVA: That's where your bucking the suit. That's the only variable, and shouldn't be hard if you can get around. You don't need battleship handholds. This idea of picking up 400 pounds or something like that: you don't have that load on you, suit or no suit. The whole thing is that you move slowly. All I can say is that the film didn't work out as well as we expected on this canister change. I had two canisters being held by me, two ... held by me, two spacers held by me, and this grounding cord all at once, and I was still maintaining my position. That's a lot of things to hold on to. It didn't bother me one bit.

CUNNINGHAM Even going into the LM from the command module should be no problem. As long as you can unfasten the tunnel, you can do it fine without water training.

SLAYTON There are some things that you do want to train on.

CUNNINGHAM We discussed this in flight, and we figured it would be hard to convince people how easy it is.

EISELE I just wanted to mention that the first attempt at landmark tracking didn't work out too well, partly because there was no way to train for it adequately before the flight. There were some pieces of data that I thought I didn't need and found out that I did: mainly, how far north or south of track the target was; and also, the fact that I could run the trunnion angle out manually to around 35 degrees rather than wait for the computer drive to run it out there and the target came into view. Once we got the procedural wrinkles ironed out and found that we did want to know how far north or south the target was, the next time we tried landmark tracking everything worked out fine. I think we got a whole series of good landmarks. Some

of them turned out to be occluded by clouds, and when that happened, we went ahead and did unknown landmarks on a cloud bank or something. In fact, it was very curious that for the first set of good landmarks we did, the DELTA-R/DELTA-V updates were zero, and yet the computer would always turn around and update the target. I thought this was kind of presumptious of it, to think that the target must have moved from what the map coordinates were. I think that was a function of the W matrix they put in. The second day we did landmarks, we did get some DELTA-R/DELTA-V updates, small ones. I guess the main point is that it is a fairly simple and straightforward task to do. At least for earth landmarks, recognizing the target wasn't any problem at all.

CUNNINGHAM I might add that it was essentially what you would call no training at all. I hadn't really been able to do any tracking at the simulator. After Donn had worked out the procedure the first day, I was able to track landmarks with no problem.

EISELE Yes.