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GT-4 FLIGHT CREW DEBRIEFING TRANSCRIPT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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GT-4 FLIGHT CREW DEBRIEFING TRANSCRIPT

Prepared by: Spacecraft Operations Branch
Flight Crew Support Division

Authorized for Distribution:

D K Slayton

Donald K. Slayton
Assistant Director for Flight Crew Operations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
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1.0 COUNTDOWN

1.1 Crew Insertion

White — The only problem during insertion was that I fogged up again in my suit before we got the fans on. I think I'm just going to always fog up in that suit of mine. We turned the fans on quick, but with the visors closed it doesn't go out.

McDivitt — We did have a problem with crew insertion on the Wet Mock and I think we had that probably pretty well taken care of. They put us on the suit loops and didn't turn the fans on. Normally you wait for a clearance from the Spacecraft Test Conductor before you throw any switches. Well, after we almost "died" of carbon dioxide poisoning during this test, we got this matter clarified. As soon as we got in the spacecraft and one of us was on the suit loop, we would go ahead and cut the switches on to put us on two fans. We did this during insertion in the Wet Mock. It really went well.

White — We really went for a long time in Wet Mock. I was beginning to wonder if I was going to have to open my visor. I was really uncomfortable.

McDivitt — But everything worked out okay on this one.

White — Yes.

McDivitt — The timing was excellent, I thought. I didn't think we had any problem at all.

White — No. I don't believe they missed a stroke on the insertion.

1.2 Communications

White — I think the communications were pretty well worked out, Jim.

McDivitt — Right. One thing, the last 3 minutes or 4 minutes, we got a little confused about who was talking to who. I was getting the Spacecraft Test Conductor, the Booster Test Conductor, and CAP COM at the same time.

White We got a split count, too, on lift-off.

McDivitt The first 3 or 4 minutes I was hearing the Booster Test Conductor. I heard what was going on on his loop, and I was listening to him get checks in from all of the guys. I really wasn't getting a clue as to what was going on. I was supposed to be getting the booster clues from the Test Conductor. I was supposed to find out when the engines were going to gimbal and when they were going to open the prevalves and stuff. I wasn't getting it from him. We were getting a lot of other information that made a lot of sense to the Booster Test Conductor, but not an awful lot to us. There were call-outs like, "Sequence 05003 complete." Well, this just didn't mean anything to us. On top of this we had the Spacecraft Test Conductor calling out the times, and superimposed on all of this was Al Shepard, the Cape CAP COM, calling out events that he was reading off that went on at certain specified times. He called out, "Stage I prevalves," and we could hear the fuel gushing downstairs and the whole booster rumbling. He called out, "Stage II prevalves," and you could hear the same thing all over again. I thought that was a lot more meaningful than the Test Conductor comments.

White I think that was wrong, the way they were doing it. I think we weren't supposed to be on any loop except CAP COM at that time.

McDivitt Well, I think what happened was that we got this thing overcoordinated. Al was going to give us all this information, but then as a result of GT-3 (Gus and John said they didn't get enough information about the boosters) they put this information on the Test Conductor's loop too. We had too many guys talking. I think if just CAP COM talked from 3 minutes on down we would be all right.

White This is the way I thought it was going to happen, and then from 3 minutes on down it really got busy with the yak, yak, yak of everybody talking.

McDivitt I don't know whether we got off the Booster Test Conductor's loop or not, but at final countdown, Al gave me 2 minutes, $1\frac{1}{2}$, 1, 30, 20, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. I got a similar count from the Spacecraft Test Conductor but it turned out that they were a second out of sequence on the countdown and Al was giving me 10 and our Spacecraft Test Conductor was giving me 9. So it went 10-9, 9-8, 8-7. They were at the

same time. All I knew was that we were getting close to engine ignition and then it started. So, we got a little over-communicated there. I think they kept us adequately informed on the hold. As a matter of fact, I'd say we got over-informed there at the end. We had too many guys keeping us informed and I think the pendulum swung from the GT-3 flight where nobody got informed of anything over to our flight where we got informed by three different people about the same event.

White — On our flight, too, we were really more aware of the problem than those people were. We could sit right here and see the gantry come down and stop. That was really the only problem they had in the whole count.

McDivitt — I don't think radio discipline is a problem. Each guy was disciplined on his own channel. They were conducting their tests on their own channel. But we were listening to three different communicators at the same time. We should have had only one. I think probably what we will need to do is to get to about T-3, and then just cut in the CAP COM.

White — That was the way it was planned to be, I thought. That's the way Al planned it.

McDivitt — That's correct. I think, because there had been some lack of information on GT-3, that it somehow had been written into the SEDR so that we were also on the Booster Test Conductor's MOPS, so that we were also getting his countdown. I think CAP COM, alone, would have been sufficient. One further comment, I had to turn my UHF volume all the way up to hear anybody. I was at max. There we were sitting right on the pad, talking to a guy 2 miles away, and there I was with the volume full up. It didn't give me much confidence as to reception I was going to get when I was 200 miles away, or 3, 4, or 5 hundred miles away. I thought that the volumn control on the radio was inadequate.

White — We were wondering what we were going to have when we got up a hundred miles.

McDivitt — That's right. At max volume we didn't have enough and at minimum volume it didn't shut it off. We will cover this later.

1.3 Crew Participation and Countdown

McDivitt I think it was just about right. I don't think we were over worked and I think we had enough to do to keep us busy.

White Actually, all we really made was a check of switches. There wasn't really too much else. Having the back-up crew run that midcount was the right solution. I wouldn't have wanted to participate in any more of the countdown than I did.

McDivitt That's an excellent point. The flight crew's participation should be the final count, not the midcount and precount. It doesn't tire the prime crew out doing a lot of chores that they don't really have to do. I think this is a good procedure.

1.4 Comfort

White Initially, the first 20 or 30 minutes, I was squirming around and I felt a little uncomfortable. But after I had been in for 30 or 40 minutes, I didn't feel there was a real restriction on staying for several more hours. I would have been very disappointed if they had said, "Well you have been in there long enough and we will work on this gantry and try it again tomorrow." I would have been happy to stay there several more hours while they fixed the gantry instead of pulling me out.

After an hour and 40 minutes, which is the end of the normal countdown, I didn't feel uncomfortable. We sat in the simulator and were a lot more uncomfortable than this. I didn't feel uncomfortable. I didn't feel uncomfortable. I had a chance to take a couple of little naps. I noticed Jim was napping too.

McDivitt Yes. I concur with Ed, although I didn't want to get carried overboard. We shouldn't scrub due to crew fatigue.

White I think it is up to the crew. If the crew is uncomfortable they should come down. But I don't think he should say, "Okay, 2 hours and 30 minutes. You cut this off," because it is an operational procedure.

McDivitt When I first got assigned to the crew, I always felt one of the toughest things to do would be lying back for an hour and 40 minutes or so prior to launch. The time we spent in the simulator lying on our back, I thought to be a very

uncomfortable position. As we went through all the training and testing at McDonnell, and again at the Cape, my back got more callouses on it. I got used to lying with my feet over my head. At launch time I wasn't a bit tired from lying on my back.

White — This is brought out in one of our last simulations, where we ran the whole 4-hour simulation and we forgot to have them tilt us up to 30°. We just got used to running that way.

McDivitt — That's right, I just don't think we should scrub the flight because of fatigue. I don't think we should do that. We weren't approaching this point.

White — We had a long way to go.

1.5 Environmental Control System

McDivitt — I think we ought to get this water management panel squared away and everybody figure out what we are supposed to do with those switches. I don't think we should be arguing about where the switches are supposed to be on the launch pad. If I hadn't asked somebody where the waste management switches should be we would have probably launched with it in EVAPORATOR. I knew that it wasn't supposed to be in the EVAPORATOR. At one of the ten thousand briefings we got on it, we were told it shouldn't be there. We ought to get this kind of stuff squared away before launch day. Thirty minutes before lift-off we were arguing about where that switch was supposed to be.

White — I wasn't confident that they knew where they wanted that switch to be.

McDivitt — Well, I didn't think we should have it in the EVAPORATOR. So, I think that water panel could have cost as much as a week's slip on our launch because they didn't know where to put those valves, and it's only got three valves on it. It ought to be made much simpler than it is. I think they should get that squared away before the next flight. Ed and I knew where we wanted it. We wanted it off and the other two switches in NORMAL and leave it alone. That's what we flew with. That's the way it ought to be fixed.

White — We can get canned, though, for not flying with it in the right position by the checklist. It didn't say that on the checklist. Every checklist we got was different.

McDivitt That's right! Each one was different. Finally we decided we were going to do it as we did and left it throughout the whole flight. Everything worked fine. We had ECS briefings by a multitude of people from MAC, including the guys who designed it. Everyone of them disagreed. It probably started out to be one of the simplest things in the whole spacecraft. By the time they got through confusing us with it, I got the feeling nobody knew what was supposed to happen to it. I consider this the most dangerous of all.

White I was convinced of that, too, after the mix-up in putting all the water in the lithium hydroxide tanks.

McDivitt There would have been about a 30-minute 4-day mission.

McDivitt The people that built the thing don't know how it is supposed to go. They had better decide this and let us know. I felt that George Roe at the Cape knew what was going on, except the Cape personnel got the valves in the wrong position and almost lost the lithium hydroxide canister full of water, with no water in the tanks. I'm not pointing a finger at George Roe. I think he's pretty knowledgeable about the system. Maybe somebody just wasn't following directions. But somebody ought to find out about the water management system and make it clear to everybody how it is supposed to be operated.

1.6 Sounds

McDivitt You can hear the prevalves, both first and second stages. The prevalves and the fluid gushing are very loud noises comparable to the engine gimbaling. I wasn't really aware that they were going to be that loud.

White I got that feeling when I read Gus and John's debriefing.

McDivitt Did you? I didn't. I got the impression that it was going to be a much quieter noise.

White Well, the whole noise level of the engine gimbaling was louder than I thought it was going to be. It surprised me.

McDivitt Yes. Engine gimbaling was much louder than I heard before. We heard this during Wet Mock and during precount and at mid-count. You can hear those engines gimbal around; they really shake the spacecraft. But I really wasn't prepared for the

big noise that the prevalves make, and such a long noise as that fuel gushing down to the bottom. I guess that was what it was. I didn't like the sounds and vibrations we got when they raised and lowered the gantry.

White It shook the whole spacecraft.

McDivitt It shook the whole spacecraft -- did you notice how it never came up straight? The spacecraft was supposed to line up kind of like this and then wham! I had visions of them knocking us off and laying us flat on the ground before we were launched.

1.7 Vibrations

White Those are closely associated with the sounds.

McDivitt Yes. I think that the engine gimbaling makes a tremendous vibration in the spacecraft and the prevalves on opening make a tremendous vibration. The gantry going back and forth vibrated the spacecraft. I don't think there is anything else, do you?

White No.

1.8 Visual

White Well, you can sure see the gantry lower and the white room disappear. That is about all you can see besides the sky.

McDivitt That's pretty impressive. That's when I sort of got excited, when the gantry went down. That's a new realm.

White I thought they were going to launch me.

McDivitt You're sitting there by yourself then, instead of all those people milling around.

I do want to make one other comment on this visual thing. We did Wet Mock about 1 or 2 o'clock in the afternoon. The sun was shining right in the window, almost straight down, such that the sun came across my visor from about just at the bridge of my nose on down. I had a tremendous amount of reflection inside the helmet, and I had a great amount of difficulty seeing the instrument panel. As a matter of fact,

I'm not sure I could have seen the instrument panel at all. Those first few seconds are extremely critical on launch. You have to be able to see those tank pressure gages. We ought to keep this in mind for those late afternoon launches.

White That is a problem, but the g loads are so small at this time you could almost forget about looking up.

McDivitt Did I fly like this for awhile during launch?

White I don't think so, but you could have. The g load is so small.

McDivitt I'm not sure whether I did or not.

White This is what we had to do during Wet Mock. We had to put our hand up and cover the window to look down at out instruments to see them.

McDivitt I'm not sure I didn't launch that way.

White I wouldn't be surprised if you did.

McDivitt I don't think I launched that way, but as we tilted over and we got in the sun, I think I put my hand up for awhile.

White Well, if the g's are so low that --

McDivitt When sun gets in your face you can't see the instrument panels because they are just too dark.

White The sun gets in your eyes. The point that Jim was making is towards a late-in-the-day launch, which we might have later in the program, there might be a bit of a problem of seeing the instruments during launch. Unless they put something up, which I really don't think you want to do. You are just going to have to put your arms up and shield the sun out and concentrate on your instruments or you won't see them. They are just gone.

There is probably a point even in an early morning trajectory as you start to pitch over where the sun will come right in your window and you won't be able to see your instruments unless you shield your eyes.

1.9 Crew Station Controls and Display

White — I found the switches all where they were supposed to be and the cockpit all set up.

McDivitt — So did I, except the comment I made on the water management system. They didn't have the control where it was supposed to be. At least, they had it in the place where everybody was arguing about whether or not it should be.

White — I certainly appreciated the work the backup crew did getting the cockpit all set up for us. Everything was ready to go when we stepped in. That's the way it should be.

2.0 POWER FLIGHT

2.1 Lift-Off Cues

McDivitt CAP COM gave lift-off, about as good a cue as you can get.

White Wasn't any question either. Boy, you could feel the first little motions of the booster as it went up. It was really great!

McDivitt I think you could feel the acceleration at release. There wasn't a doubt in my mind that we were loose.

White That's right. I don't know if I could feel the bolts or hear them.

McDivitt As a matter of fact, it seemed to steady out a little bit. The vibrations seemed to decrease a little. Pretty impressive!

Not much vibration at lift-off. Very low.

White Very low. I got vibrations later on, though, didn't you?

McDivitt Yes.

Noise. There wasn't much noise, was there?

White No. There was less than I had expected.

McDivitt Noise wasn't a cue to lift-off. Noise was there if you were bolted down all day long. I don't think the noise changed a bit at lift-off.

White You could see the visual cues out the windows. You were watching your gages, Jim.

McDivitt Were there clouds out there?

White No, but I could see it in the clear blue sky.

McDivitt Could you?

White Yes. I could see the motion.

McDivitt Okay. Well, I couldn't.

White I was looking out.

McDivitt I saw a little cloud go by and then I didn't see any more clouds at all.

White It was beautiful!

McDivitt The event timer started just like it should. Of course, that's the best display inside the spacecraft for lift-off. The event timer starts, and it did.

White We got both clocks started with the time hack. I had a watch hack on lift-off and the ... handle going. I knew when the engine ignited, within half a second accuracy. Three seconds later I was waiting for the lift-off and it came right at 3 seconds.

McDivitt We could tell ignition, too. We could hear the things go.

White I agree with you. I knew we weren't going to hold it when that lift-off went.

2.2 Roll Program

McDivitt Roll program came in at 10 seconds just like it was supposed to. It was smooth, and it was just the way it was planned, on at 10 seconds and went out at 20 seconds. Could you see it roll out the window?

White You can see everything out the window, I think.

McDivitt You can probably tell by the way the sun rays are moving, can't you?

White Yes, by change in lighting. The right seat has a better view. You have to watch the gages so closely.

McDivitt I didn't even look out the window.

White I know you didn't.

2.3 Pitch Program

McDivitt Pitch program started just like it was supposed to, at 23 seconds. Pitched over the proper amount, the pitch needles looked like they were hanging in there all the way.

White — You could see the booster pitch definitely, and that was mainly due to a change in the lighting.

2.4 Aerodynamics

McDivitt — We were getting aerodynamic noise, which built up to max q. We got some pretty good vibrations at max q.

White — That's where I had the most vibrations. It was just shaking like this.

McDivitt — It was vibrating and noisy.

White — That was the loudest noise we received the whole flight.

McDivitt — Right after max q it got very quiet.

White — This is where I had the most vibrations. There were more than I expected.

McDivitt — Yes, me too. You can't simulate this in a simulator. You get more vibrations than you do noise. The only thing they have in the simulator is noise; they don't have vibrations. It was pretty loud and the spacecraft was actually shaking around a lot. It was really vibrating.

White — Yes, it was. More than I expected.

McDivitt — The whole thing was really going at it. Almost like a F-80 or a T-33 at about 0.8 Mach.

White — Very good analogy.

2.5 Environmental Control System

White — The cabin started venting shortly after lift-off and continued so until about 40 seconds and stabilized out at 5.5 and I made my call in. I think I might have called in on RECORD.

McDivitt — You did.

White — I switched and made the final call at about 1:10. I realized I called on RECORD and switched over.

McDivitt — How high did it go? Did it go to 5.5?

White 5.5 and it stayed right there. And then I noticed later on it progressively leaked off until it got to 4.9 where it stayed. The suit? There really isn't anything to say about the suit.

McDivitt No, I don't have anything to say about the suit. It operated like it was supposed to.

2.6 Maximum q

McDivitt The noise built up gradually until we got to max q, then it just dropped off.

White The deterioration of the noise was almost instantaneous.

McDivitt Very quick. It wasn't instantaneous, but it was very quick.

White In fact, it startled me when we separated.

2.7 Windshear

McDivitt I didn't notice anything on the rate needles that had anything to do with the windshear. I couldn't pick out windshear on them. How about you, Ed?

White No.

McDivitt Did you see any attitudes?

White No.

McDivitt No big divergences from windshear.

2.8 DCS Updates

White We got both of our DCS updates right on time — 1:45 and 2:25.

McDivitt No comment. Ed is in charge of DCS updates.

White I'm the button pusher. I do everything about pushing the buttons.

McDivitt I can do this with this little stick.

White You can do it unless I have my knee over it.

2.9 Engine 1 Operation

McDivitt They operated the way they were supposed to as far as I could tell. The tank pressures stayed up fine on both Engine 1 and Engine 2. There was never any doubt in my mind that they were going to stay up there. There weren't any of those things like we saw in those simulations where they came on down pretty low on the gages when they were supposed to be at 18 or 15. There wasn't anything like that. They just stayed on up there.

White Just where they were supposed to be.

McDivitt Yes. I followed them a couple of times and said they were staying up fine. They were way up. There wasn't any problem there.

2.10 Engine 2 Status

McDivitt Second-stage pressure stayed right on up there very high. Just the way they were supposed to. There wasn't any problem there. They didn't decay all during the first stage.

2.11 Acceleration g's

McDivitt They weren't bad, and I don't know where they went to on the g meter.

White Just like riding in an old saddle.

McDivitt That's right. It's very comfortable. Steady onset.

White Not very long. Gee, we were below --

McDivitt Wait a second. This might be a good place to cover the POGO. I felt the POGO just prior to staging, from about 2:15 on to 2:30. I could feel POGO.

White How much were you getting?

McDivitt Very little. I could just feel it pull like this. Did you feel it at all?

White No.

McDivitt I could feel it. It wasn't uncomfortable enough where I had to lift my head or anything. I wasn't thinking about POGO at all. It wasn't like I was trying to sit there and think about it. But as we were going along I could feel this vibration. And then it just crossed my mind: well there is POGO, and then we went on to staging. But it wasn't bad at all. The amplitude must have been --

White You were paying more attention to your clocks while I was watching the system gages, and I wasn't really aware of the times that were going on. I had my eyes --

McDivitt It came around 2:15 or so and lasted to about 2:30. Maybe it was 2:10 or 2:05, but it wasn't bad.

White We had one area that I will get into later that I haven't told you about and that I didn't like.

McDivitt Oh. So, I think we hit the POGO and the g's.

2.12 BECO

McDivitt Engine shut down properly. The lights came on. Engine 2 light went out and the Engine 1 lights went out. Just the way it was supposed to at BECO and staging. Two Stage 1 lights ON, Stage 2 light OFF, Stage 1 lights OFF.

White At that time I realized that we were going to feel the pyros and stuff -- feel the separation. It was a very distinct feeling when we separated. Of course, we immediately dropped in the thrust. There wasn't any question, we had a good separation, in my mind. This is just the way it was for all of our separations. Everytime we separated, it was very clear that was what had happened.

McDivitt Oh, yes, there wasn't any doubt about it when that first stage shut off -- Voom!

2.13 Staging

McDivitt Staging was just as it should have been.

2.14 Engine 2 Ignition

McDivitt Engine 2 started right on up. Like I mentioned earlier, the light went out and the tank pressure went down just a tad, but it stayed way up there, about two or three times as high as was necessary for staging. It never really did decrease. It stayed up around 45 or 50 psi, and we need 20 for staging, so --

White I couldn't hear anything.

McDivitt Didn't you hear the engine?

White No. I was listening but it still was quiet.

McDivitt I didn't really get much of a cue out of it at all, except the lights went out and I could feel a little bit of acceleration.

White The acceleration decreased. Another thing I didn't get -- I got absolutely no pitch-up associated with the way the centrifuge does you at the end of an acceleration. I think that is associated with the cab on --

McDivitt Yes. I think that's the way they rotate those gimbals when you come on down. If they rotate them a certain way you can get that pitching-up --

White A very safe forward-type deceleration.

McDivitt I think that pitching up on the centrifuge is not a malfunction. It's just the programing that's hooked into the gimbals during the stop program. You've got to get them all going the same way so that you keep the vectors through you. During launch the vector is right through you. It's not varying around, but in the shut-down on the centrifuge those darn gimbals aren't always synchronized together. They get shifted back there and it gives you that peculiar sensation.

2.15 RGS Initiate

McDivitt Well, I was really watching closely but my rate needles just barely changed. We must not have had any errors at all.

White Yes, I got a full error.

McDivitt Did you have a full error?

White Yes, my pitch error went all the way down, and then it just steered slowly right back up. Remember you --

McDivitt You did call and tell me you had a saturated -- Did you call saturated, or did you say we had a big one?

White I called it saturated, I believe.

McDivitt That's right.

White I called a saturated error, and then I called you that it was steering back to zero.

McDivitt Yes. I remember that you did call that.

White That's the way they showed this on the plot, that it would saturate there, and very quickly it seemed to gradually steer right back up.

McDivitt The steering rates that went in were on the order of less than half a degree per second.

White They were very low.

McDivitt Very, very low because I was on high scale. The needle just barely deviated at all at RGS initiate.

White It was beautiful steering.

McDivitt Nominal, nominal, nominal, except like that saturation on the error needle, but we have been briefed on that.

White That's right. That's something to be expected.

McDivitt When did it saturate?

White Right at staging. No, right at guidance initiate.

McDivitt Oh, okay. It saturated right there.

White Right there at guidance initiate, which is what you'd expect.

2.16 GO-NO-GO

McDivitt They said they were GO and I said we were GO. There wasn't much problem. Ed and I had been checking back and forth on the systems. I knew they were all right.

2.17 Systems Status

White The systems were all pretty good. There was only one I didn't like, and that was the stack readings on the main ammeters. One was reading about 28 and the other was reading about 14. But I felt that this was associated with bringing the batteries on. I went through and checked everything. Everything was reading properly. The control bus and main bus were all reading all right. I felt it was just a misbalance of loading. I talked to somebody previous to this time, and it was explained to me that this could happen this way. I felt perhaps it was in the adapter batteries -- would feed through on one of the stacks causing one of them to take more than the other.

McDivitt Yes. You could have gotten into the knee of an adapter --

White This is what I had figured — that a couple of my adapter batteries were unbalanced, causing this to occur. I also had seen this on the simulator quite a few times.

McDivitt When did the unbalance start? When we got in they were --. As soon as we were on internal power?

White Right. And I didn't feel this was the time to talk about it. I was still under 30 amps, which was my point. So I didn't bring it up.

McDivitt You didn't want to worry me?

White I didn't want to worry you, and I didn't want anybody on the ground to start hollering about it.

McDivitt You should have written me a note.

White I did feel that this was exactly what it was, that it was adapter batteries. That was the only abnormal type of indication we had in the systems. They were all real good.

Well, we had good communications with the ground during powered flight.

McDivitt We had pretty good communications. I called the "Roll Program," and nobody answered me. I said, "Well, to heck with it, maybe they just aren't getting through." Then I was just starting to call Roll Program complete when Gus called and said, "Did you get the Roll Program?" Now that was the only transmission I made that wasn't acknowledged.

White Yes, I heard you calling, too.

McDivitt So, if they lost communications it must have been right at the 10-second time, and it should have been for less than 10 seconds. It couldn't have been for more than 20 seconds. I heard the countdown to lift-off, and I heard Gus call and ask me if I had the Roll Program started. This was a little bit less than 20 seconds — around 18 or 19 seconds. That is the only period of time I didn't hear anybody I should have heard. So, if we lost communications, that was where it was.

2.18 Acceleration

McDivitt Well we got up to $7\frac{1}{2}$ g's. The acceleration wasn't bad at all. I guess when you are really interested in what you are doing like on the boost or reentry, those g's don't mean anything. I don't like to ride the centrifuge. $7\frac{1}{2}$ g's is $7\frac{1}{2}$ g's on the centrifuge, but on the booster --

White My vision was crystal clear.

McDivitt Me too. I wasn't even breathing hard. I wasn't huffing or puffing or anything. I was just lying there relaxed.

White Particularly on this one. The acceleration during powered flight and insertion was very light.

2.19 SECO

McDivitt SECO occurred as it should have on my clock. Ed thought it was about -- what did you say it was?

White I thought it was a second or so early, and it concerned me because that meant we were going to have to burn. So I was quite expecting to hear a big ΔV come up from the ground. There is no question on that SECO either. It shuts off and you get that linear straight deceleration.

McDivitt The thing that surprised me was that we weren't talking about it at all. We were just going as straight as an arrow when that thing shut off.

White There weren't any oscillations or roll.

2.20 Steering

McDivitt I was getting a sinusoidal oscillation on my rate needles, and I don't know now whether it was pitch and yaw. I called it out at the time, to you anyway, Ed.

White Right. And my attitude errors were --

McDivitt Your attitude errors were right on? Okay. But I was getting an oscillation, very small, about plus or minus a quarter degree in rates. Not so that the needle was actually moving back and forth across the dots. It was pretty obvious that it was. Now, I sort of felt that I could feel that movement a little bit, like this, but not annoyingly, and certainly the stabilization was holding it close enough. But it wasn't that the rate needles were just constantly oscillating back and forth. It seems to me it was in pitch, but I'm not really sure. A booster pitch.

White The attitude error needles were the only deviation we had at any time. Yaw was just about nominal all the time. We had the pitch deviation at guidance initiate. It went to full scale and steered right back in, and also right at the end we had, in pitch, a little bit of a pitch-down needle indication which increased to no more than about a degree at booster shutdown.

McDivitt You got about a degree, then, on shutdown?

White Just about a degree.

McDivitt Yes. I kept glancing over to see how you were doing. They were always right near the center for me.

White Yeah. Right near the end they trailed down just a little bit. I'd be interested to see what the ground thought on this.

McDivitt Yes. You'll have to go over and look. I'm sure they have them.

3.0 INSERTION

3.1 Post-SECO

McDivitt Yes. There was a Post-SECO. In the period between SECO and SECO + 20 seconds, I unstowed the maneuver controller. I don't know where our attitudes were. They were the same as they were at SECO, and it was about 20 degrees pitch-down, wasn't it? The rates during this period were on the order of less than a half a degree per second. We really had a period of from SECO to SECO + 30. So, during this time I actually fired the translations thrusters at least two times in one axis to kill off the rate in that axis, and I think it was probably the booster yaw or spacecraft pitch where I actually fired the thrusters once or twice to bring the rates back. It might have been the other way around. But we didn't jettison the fairings then. I did unstow the maneuver controller, and the attitude was the booster burnout attitude and the rates were very low, less than a half a degree per second.

White I think we mentioned prior to this time the feeling that we came off a little half-cocked off the second stage.

3.2 SECO + 20 Seconds

McDivitt We were going to stay on the booster until SECO + 30 instead of SECO + 20. At 20 seconds the IVI's started displaying, and I read them off as 20 forward, 11 right, and 5 down.

White Right.

McDivitt This was when we were still in the 90° bank position. Is that correct? Or was it after I had rolled right-side-up?

White It was after you had rolled right-side-up.

McDivitt Okay. Well, then the IVI's displayed when we were still on our side. It seems to me they were about 25 feet/sec forward, and some other numbers, but anyway they were low enough where I felt we were certainly in orbit. At least the IGS was telling us we were in orbit. During this time, as I said earlier, I tried to damp the spacecraft rates, the spacecraft booster rates, which were quite low. I checked to see that the OAMS Power Switch was in ATTITUDE and MANEUVER, and to see that Ed had switched over to DIRECT. I told him

I was going to do some thrusting but I wasn't going to separate yet, so that when he heard the thrusters go off he wouldn't push the SPACECRAFT SEP. Then we did separate the spacecraft with the exact routine we practiced in the simulator. I said, "Thrusting, separate," and you punched the SEPARATE button and I guess you went to Rate Command. I thrusted straight ahead for about 5 seconds. This is where I think we came off crooked. This is the part Ed was mentioning before. We didn't seem to come off straight ahead. We seemed to be getting some sort of an oscillation that got us going in a different direction than what we had going on the booster.

White It seemed like one side of the separation plane came off with more force than the other.

McDivitt Yes. That's what it seemed like to me.

White It separated at a bit of an angle.

McDivitt That's right. We didn't separate fore and aft; we separated with a lot of rotation to this side.

White Yes.

McDivitt Air-ground communications were all right. We were talking to them and they were talking to us. I never had any problem there.

White Shortly thereafter they called up and told us we had a 153 by 57 orbit. So they were talking to us. I don't think I ought to read off this stuff now, but they gave us a 2-1 data and all the nominal data we were supposed to get. It came out fine.

McDivitt Say again what the IVI's were while we rolled right-side-up.

White Right. At the position we decided on taking our IVI readings, which was heads up in a zero-zero attitude. You read off the IVI's to me as 20 forward, 11 right, and 5 down.

McDivitt Okay. Then I didn't bother nulling the pitch needle because we were really pressing for time to get around.

White No velocity correction was called up to us, and since we had no velocity correction and we were fairly busy at this time, I didn't even read out the 52 or 70. I wasn't particularly interested in them. It's a funny thing though -- 52 was punched in and had been read out and it showed 30. It

had been punched in so it read out, you see, as soon as something came in the quantity. So, I did have a readout. I read out 30. I remember looking at that.

3.3 Insertion Activities

McDivitt — I thrusted and got off the booster. Then I went ahead for just a short time, and then I started to turn around right away. During the turn-around, I jettisoned the fairings. They went off with a bang. I could see the fairing over the horizon scanner go, but I never did see the fairing off the nose go. I just assumed that it went. We were already in just a mass of debris up there, because when we separated from the booster there was stuff all over.

White — All over. It really flew by to the side of the spacecraft.

McDivitt — Yes. It was all over the place. As we were turning around it looked like we were going through a snow storm. There was stuff all over. Finally we got turned around, in about a minute and a half, and we could see the booster there.

White — There's one thing I would certainly like to see somebody do — I'd have given my right arm to have had a camera when I turned around and saw the booster. I'd like to see somebody carry a camera in a semi-stowed position so he could immediately get it out and come around and take pictures of the booster. Either the camera, or better yet a 16-mm camera with a normal lens on it. Just tuck it to the side of your leg. If I had thought about it, I think this is what I would have done — just connected the camera, tucked it by my leg, and taken pictures of the booster at this time.

McDivitt — I think, Ed, this is probably one of those philosophical things. On the first orbit you've got to save to prepare to come back in case you have a bad spacecraft. You've got to be ready to reenter during the first orbit. This is the kind of bind we found ourselves in up there. During the first orbit we really had a lot to get ready for halfway through the second orbit, but on the other hand, we had to be in good enough shape so we could reenter it at 2-1. Now, we didn't have anything to go wrong so there wasn't any problem, but I think when you first get into orbit you're in a problem. This kind of a thing, I think, is a problem you may have later on. You've got to be ready to eject at lift-off plus 1 second, and you don't want to be sitting there holding a camera or something like that. Both your hands are busy.

But like you said we could stow it somewhere.

White — I think you could. You could stow it beside you in the seat. I think we over-emphasize the necessity, particularly for ejection, of having to have everything stowed when you are only ejecting up to 12 000 feet and at very slow speeds. We certainly have a heck of a lot more working against us in our airplanes we're flying around.

McDivitt — That's right. I agree with you. I'm just saying this philosophy of being completely prepared to reenter during that first orbit is in conflict with doing this kind of stuff in the first orbit, too.

White — We ought to get some of this, though. I think we are missing things. I would have really --

McDivitt — Yes, I think so. We could have really had some beautiful pictures of that booster when we were close to it.

White — I also want to comment a little bit on the booster itself. I looked as closely as I could at the nozzle skirt and the aft end of the booster, and I saw no damage whatsoever.

McDivitt — No, neither did I from our vantage point.

White — As far as I could see, the nozzle skirt was completely intact. There was nothing wrong.

McDivitt — Okay. Let's try to follow this insertion activities list here. I jettisoned the fairings, as I said, as soon as I started turning around. Then Ed went through the checklist for us. After I fired the fairings I turned off the BIA switch and the retrorockets when he called. I was probably doing this before Ed called, wasn't I?

White — We did things just like we had been doing them on the simulator. We don't just take a checklist and run down it item for item because there're things you have to be doing, and it just doesn't go in a sequence like that. I realized this was the way it was going to go, and I actually took a pencil and checked items off. If you did an item I checked it off, and if you didn't I left it unchecked and we got it later. You just can't expect to run down the checklist item for item because you're not ready to unstow your life vest or to get up out of your seat belt. You don't do that for some time. I think the logic on the checklist we have here is a very good sequence --.

McDivitt We reviewed that checklist 50 times. That's probably the fiftieth checklist we've got there, and I don't think it could have been arranged any better for the two of us.

White I knew Jim wasn't going to undo his seat belt harness and I knew I was going to have to because I had to do certain things that he didn't have to. The point that I'm making is that the checklist doesn't have to be accomplished item for item, completely done in numerical sequence.

McDivitt Okay. I think we'll revert back to the exact subject of 3.3 now, safetying the switches. I safetied the switches — the BIA Squib Switch and the four Retrorocket Squib Switches. I tested the sequential lights, but at a later time because I was involved in turning the spacecraft around. But I did test them. As far as stowage, I stowed my left arm restraint and my D-ring, but I did not push my safety pin in.

White I went through and put my arm rest down, put my safety pin in. That was one of the first things I did.

McDivitt I might comment that I never did put my safety pin in. I never put the safety pin in the D-ring. I felt the D-ring cover was adequate, and it was.

White I know. You never have been particularly too hot on that.

McDivitt No.

White Then I went ahead and disconnected myself. I had a lot of things I had to squirm around and do. I left my life vest on as we had planned to do, then take them off leisurely at a different time. I did not find any reason to put the drogue pins in. I don't think they are satisfactory in anyway. I don't think the pin itself is satisfactory, and I don't think the location or type of holes are satisfactory. I will elaborate on them a little further. We have had aircraft around for a long time, and we have learned a lot about safety pins. We have come up with some pretty good designs on safety pins. We have a design on our drogue pin right now which is no more than the very first type of safety pin that I saw on an aircraft. I think that we are past the point where we should be starting right out at the beginning. We ought to put a properly designed safety pin in there that you can insert a little easier into the holes. I'm not going to try to design the pin, but I think that it should have some type of shaft on it that you can use to stabilize the pin when you insert it. And when I say the holes through which you

insert the pins are unsatisfactory, I'm referring to holes through a cylindrical shaft that is hollow inside so that you not only have to find the hole to put it in on one side, but you have to work it around and find the hole that it goes through on the other side. I don't believe that's satisfactory. I don't think the opening into the hole is supposed to be beveled, and they weren't beveled on my seat and they weren't beveled on Jim's seat, either. I think a beveled hole is a hole that is bigger on the outside than it is on the inside. I don't believe there is much difference between the outside and the inside of the holes for the drogue pins. I had a difficult time putting my own in. I put Jim's pins in. It took me a while, but I put them in. I never did get one of mine in satisfactorily at this time, so I think we should do something better with the drogue pins. In addition, I couldn't even see the hole.

McDivitt You had an easier time putting my pin in than you had putting your own pin in.

White That's correct. I could put yours in fairly easily.

McDivitt That's right. I think that when you turn towards the center of the spacecraft, you end up with more room than if you turned to the outside. You can't see a thing if you are turning toward the outside.

White This is probably covered later, but my hose lengths were not long enough to permit me to turn all the way around. I knew this when we went through Weight and Balance. I knew my hoses were not long enough, but it was too late, as far as I was concerned, to change them at this time. But I couldn't see the holes on my side to insert the drogue pin. I couldn't see the holes for your drogue pin either, but I could get a better view of them over there so I knew approximately where to put the pin. I think in all respects the drogue pins are not satisfactory. You just can't see them, the pins are incorrect, the holes are incorrect, and I think we can certainly do better with them.

McDivitt I think what Ed is saying is that it's lousy.

White That's right. In two-letter words, it stinks! This is the way the batteries were reading out when I checked them at insertion. And this is what I had suspected they were doing when we launched -- why we had unbalanced stack readings. 1-A read 6 amps, 1-B read 10, 1-C read 11. This accounts

for your high reading on Stack 1. 2-A was 6, 2-B was 6, and 2-C was 6. This was the way they were reading. I ran through a check on them when we were actually in the booster phase. So that is why I felt the reading wasn't bad. They were both reading about $23\frac{1}{2}$ or 24 volts. They looked pretty good.

I got my 2-1 update. I got the ΔV of 167, ΔT of 3+35, and G.m.t. to retro command of 14:48:34. I have the other times too. The time to 400 000 was 2+18, as read up to me and the time to reverse bank angle was 8+47. This is what we wrote down. This is one time I remember now when I was a little irritated, because they gave times to us in a manner in which I hadn't wanted them to. They were supposed to give elapsed time but they gave it to us in G.m.t. time for our retro. We had asked them to give it to us in elapsed. They came right back up and gave it to us both ways. I remember writing it down twice, on the elapsed time of 01:32:35. I can see why they did it because it was 2 minutes past 1 hour 30 minutes, and I guess they weren't sure exactly what we wanted. So they gave it to us in G.m.t. and elapsed time also. But that is the information we received, as far as our 2-1 area was concerned.

McDivitt I think Ed had better cover unstowage. I didn't unstow anything. I was just trying to stick with the booster at that time.

White The first thing I got into was my right-hand stowage compartment, and I unstowed the blood pressure bulb. Then I started into the center section to get at the camera. The first thing I wanted to get out was the Hasselblad and the 16-mm. I was dying to get a picture of that booster. So, I unstowed the Hasselblad and got a good back on it and the 16-mm camera. I didn't unstow the urine nozzle as the flight plan had called. We both had decided we were going to use our launch-day urine bags as long as we could, and we had hoped to use them right through the EVA. As it turned out, we did. That was about all I unstowed at this time. I unstowed the cameras, the blood pressure bulb, and also got out the film cartridges and tape cartridges. I put them on the side of the foot well, where I planned to keep them, so that we could keep a good tape cartridge available.

4.0 ORBITAL FLIGHT

McDivitt I think that the orbital flight should be broken down into some very distinct sequences. I think there are really three of these. The first one is about the first three or four orbits where we were trying to stay with the booster, where we did the EVA, and where we finally got back in. The time that we finally got the spacecraft depressurized ends one phase of the mission. The next phase or sequence of the things that come along is really the second phase. This is the middle 50 orbits or so, where we did the experiments and where we did the flight plan in a highly modified manner. We did the flight plan we started out to do. And the last phase or series of sequences was the retro-preparation, retrofire, and the reentry. The retro-preparation was actually another distinct phase of the mission. I think that we ought to divide it up into those three phases -- the station-keeping and EVA as Stage 1, general orbit as Stage 2, and retro-preparation and reentry as Stage 3. So I think we should start in the orbital flight with the station-keeping on the booster. I think that we should just pluck that thing out and follow it through in its entirety, and then come back and pick up these things like the thrusters, Control Mode Checks, Com Checks, and those things.

4.1 Station Keeping

McDivitt The station-keeping with the booster -- Well, as I said earlier on the insertion phase, I started turning around as soon as I completed the forward thrusting. I jettisoned the nose fairings after about 30 or 40° of yaw. I rolled right-side-up, and then I started yawing around to the left. We saw all kinds of debris floating around, and we finally saw the booster back behind us. It was already in a peculiar attitude. As Ed mentioned, when we separated from the booster, it didn't really feel like we came off straight ahead. It seemed like we got knocked off to the side of the thing. The spacecraft-booster combination sort of bent in half at the separation plane. We yawed on around and saw the booster, and I thought it was around 400 feet back. Ed thought it was a little closer.

White I would estimate it at between 200 and 250 feet.

McDivitt Okay. We were in pretty good shape right then, and I applied about 5 or 6 seconds of thrusting that should have come out around 5 feet/second. I was in a hurry trying to get our separation velocity stopped, so I was thrusting. I had it in Rate Command. I pointed the spacecraft at the booster and started thrusting, and by the time I got the computer in the Catch-Up Mode and the Start Comp button on, I had already thrusted 2 or 3 feet/second out, and I counted up another 3 feet/second on the IVI's. It looked like we were probably stopped, although I couldn't tell that quickly. I knew I had as much ΔV in there as I had at separation, and possibly a little more, because I tried to hold the separation ΔV down to no more than 5 feet/second. We watched it for just a short time and then it was obvious that we hadn't stopped our separation velocity -- our relative velocity -- so we were still separating. So, I applied about another 3 or 4 feet/second, which should have more than overcome the 4 or 5 feet/second I put in initially. It looked like we had stopped then. Our relative velocity looked like it went to zero. Here, I thought, we were out around 500 or 600 feet. Ed thought we were probably in closer than that.

White Yes. I thought we were in a little closer.

McDivitt I put in a total of around 9 feet/second in the first minute and a half after we turned around.

White I think we commented together on the speed with which the booster was going away from us. Right off the bat it looked like it was -- it surprised me that it actually looked like it separated from us as fast as it really --

McDivitt It looked like it had a lot more velocity than the 4 or 5 feet/second I added at the separation. It looked to me, as an off-the-top-of-my-head-guess, that something in the spacecraft separation thing had really built up a lot of relative velocity between the booster and the spacecraft. I don't know why or how. Also, it looked like we weren't in-plane anymore. It was actually out-of-plane so that we had an out-of-plane relative velocity that I took out. I pointed at the booster because, obviously, if you're separating away from something, whichever way you're going, if you point at the thing and if you thrust in that direction you are to take out your relative velocity in all planes. So, it looked like the thing was off to the left or to the south of our orbital track by a couple hundred feet and it was going down rapidly, losing altitude. After I thrusted this second time, I knew I had more than enough velocity, much more than I needed to

kill off the 5 feet/second we'd added. I watched it, and it looked like it wasn't going from us anymore. It looked like our relative velocities had stopped. I wanted to get the platform alined somewhat, in case we did have to come down in the 2-1. We really hadn't had much chance to check over the spacecraft yet. So I quickly went to as close to zero-zero-zero as I could get. I used the zero yaw and the zero roll off the ball and I went to a pitch attitude that looked like it was about zero and tried to get the ball to aline to zero-zero-zero. At that time the booster was mostly behind us -- mostly back toward the Cape from us -- back behind us with respect to our velocity back there. It was in the window and I could see it. Well, I started alining the platform and left it there for a couple of minutes. The booster started falling again, descending below us. It actually went out of my view in the window. At the time, though, our relative velocities were quite small, so I felt I could let it go for another 30 seconds or a minute and not have it get very far away from me. It looked like it was coming toward me again, but going below. So, I allowed myself about another minute and I pitched down and looked for it. It appeared that during that minute it had gone a lot farther down than I had expected it to go.

White Yes, I was surprised. Remember that it looked like the orbit was surely something different than we predicted.

McDivitt Yes. It looked to me like the booster and the spacecraft weren't in anything that even resembled the same orbit, at the rate it was descending. I don't know what the range rate was at that time. It looked like it was a lot more than a foot/second, though. I don't know what it was. I quickly pitched back up to zero-zero-zero and stayed there for about another 10 or 15 seconds and went to Orbit Rate. I knew I didn't have a good alinement on the platform, but I knew I couldn't stay there any longer and have the booster anywhere near us. So, I flipped around and pitched right straight down and here's where the problems started. To get down to the booster in a long rendezvous-type maneuver, what I should have done was to just stay horizontal and fire retrograde and take some total velocity out of the spacecraft. But when you do this, the booster continues to pull away from you for a while, and then eventually you are going to drop down below it. Then you are going to be in a lower-altitude orbit, and you are going to pick up and catch up with the booster. Well, with the station-keeping we had to do and the fact that the darkness was only a matter of another few minutes --

White Boy it was fast!

McDivitt It wasn't any time at all. I didn't have time to play a rendezvous game with it. I had to overcome this relative velocity we had with sort of brute force, so I thrusted right at the booster again. I got going down and I used about 5 feet/second there. Here's where the numbers get a little vague. I thrusted down at it, and I watched it go for a while. I thought sure we'd start closing on it again. We weren't closing, so I thrusted down on it again. I must have done this probably three or four times. I can't say exactly.

White I don't remember, precisely, how many times you thrusted. I was keeping my eyes on the booster.

McDivitt And it was a lot tougher to see when it was down with the ground as a background, I thought, than with the sky as a background. During this period of time its rotational velocity picked up considerably, and during this time Ed checked it and got 8 seconds for a complete revolution.

White A complete revolution. Yes. This was an estimate.

McDivitt This meant that in the first 3 minutes after we were in orbit the thing had gone up to a rotational rate of 40 to 50 degree/second. It seemed to stabilize at that rate. Its rotational rates stabilized but I don't believe its rotational mode ever stabilized. It didn't rotate in a plane as I thought a long body like that would rotate. It seemed to oscillate in just a random tumbling fashion. It was all over. It looked to me like it was rotating in three axis in a completely unprogramed manner. It might have been that the roll nozzle was flopping around and the fuel was turning it around in different directions. And as a matter of fact, at this time we should go back and draw a picture of what the fuel looked like and what was coming out of the nozzle. The booster was tumbling and you could see the fuel squirting out of the roll nozzle in a big fan like this. I had the impression that if the booster were perfectly stationary, the fuel would have been coming out of the nozzle in a great big cone the way you would expect it to, but because the booster was tumbling so rapidly it was coming out in a long, twisted -- like a horn of plenty. It was very obvious; you could see it, and there wasn't any doubt about the fact that there was a lot of fuel coming out. Whether this was contributing some thrust to it or not I don't know.

White I want to comment on something that was quite an experience for me. When I called out to you, I was looking down at what I thought, since it was pitch black, was the sky. I could see little sparkles everywhere. And it looked like almost a starlit sky, but it just didn't quite look right to me; it looked like an artificial starlit sky. It looked like some of these star displays they have created for us. And I looked over at Jim and asked him if he was seeing this and about the same time I noticed that he had nothing but daylight out his window. This was the first time that I had the daylight-dark experience of one guy looking into pitch black night and the other guy looking into a complete daylight window over there. Jim remarked rather disgustedly to me, "We are pointed straight at the ground!" About the same time I realized I was looking out at the fireflies everybody had seen, but probably in a much more profuse quantity than had ever been seen before, because we were getting all this fuel that was vaporizing into many, many particles from the booster and a little bit of a contribution from the spacecraft also.

McDivitt And we were thrusting, too. I'm sure we had all that junk on it from our launch.

White That's right. And the whole area out in front of my view was just entirely taken up with these little particles, and this was at sunset. As the flight progressed, each time we had a particle or a group of particles such as a urine dump right at sunset or sunrise, the sun would pick these particles up and they would act just like little magnifying glasses and make very bright spots. This is exactly what happened. Did you ever see that then? I think you were more in the daylight side.

McDivitt No. I was on the daylight side. I didn't see what you were talking about.

White It was really something. The whole sky within my view was covered with these little particles — thousands of them. There was obviously a great deal of that stuff in the air all around.

McDivitt As soon as we got turned around I could see that the lights were flashing on the booster, and Ed saw them, too. It was pretty apparent. I called out right away to the ground that the lights were working. I don't know if they understood what I was talking about or not. I also called out shortly

after we came off the booster and we saw it, that it didn't look like we were going to be able to touch it, because of the high rotational rates that we already had. We were into darkness by the time that we got turned around, and I had thrusted just two or three times at the booster. We were still quite far above it -- I would guess now on the order of 2000 feet or more and it was still dropping away from us rapidly; I had already used about 25 or 30 feet/second to get toward the booster. I knew I had to catch it during the nighttime, because when we came out of the darkness on the next pass, we had to be next to it, because we were supposed to take some photos of it around that time. So I thrusted some more right at the booster trying to just overcome orbital mechanics with brute force. It was too late to start playing fancy games with the orbital mechanics. Finally, I got us down to what I considered a good position, and this was prior to Carnarvon, I believe. Remember when we finally got it on the horizon?

White It looked like it had finally stopped.

McDivitt The relative velocity had finally stopped. And let me now make a general comment about what I thought of the lights on it. We had two lights on the booster that flashed and they were diametrically opposed on the center of the booster. And when the booster was in such a manner that I could see both of the lights, I could tell relative rates and I had an idea of how far away I was. Did you find this to be true, too, Ed, or not?

White Well, I can't honestly say I was looking at it with that feeling.

McDivitt Okay. Well, what I am saying is that it was difficult --

White I want to hear what you are going to say. I'm not sure what you're saying yet.

McDivitt It was difficult to tell how far I was away from it, at best, but when I had the booster in such a position that I could see both lights at the same time, I could tell by the distance between the lights whether I was close or far.

White Okay. I agree with that.

McDivitt And when I could see these lights flashing over a period of time, I could tell whether the distance between them was getting larger or smaller so that I knew if I was closing or

not. Unfortunately, because the booster was tumbling in this screwy manner, I couldn't maneuver around the booster because it was tumbling so fast; I was just trying to get close to it and not even maneuver -- not to pick specific positions. All I wanted to do was just get close enough so I wouldn't lose it. When I could see these two lights, I had a pretty good impression of whether I was closing or opening. For a long part of the early part of the mission in the nighttime it looked like we were holding our own, and then we finally started closing with it. I finally worked it down where we were at the same level. All this time I had been above the booster. I worked down until I was at the same altitude with it; at least it was on the horizon. I felt that by then I had gotten the thing under control, and we stood a pretty good chance of still coming out on the daylight side with the booster. I can't tell you what the range was. It looked to me like I had worked the range back down (it had been opening up as we went into darkness) -- to 2000 or 3000 feet again -- probably around 2000 feet. It might even have been as low as 1000 feet. It could have been lower than that. At one time I got the impression that we were quite close to it.

White Yes. You were wondering whether you should retrograde away from it.

McDivitt It looked to me like we could have gotten as close as 200 feet. It was extremely difficult to tell how close we were. What's your guess, Ed? Just pick a number.

White I wouldn't say that close. I'd say you're more in the ball park in the neighborhood of 700 to 1000 feet.

McDivitt Okay.

White You could be magnitudes off.

McDivitt Before we got to Carnarvon, I remember, we were in reasonably good shape, because I had finally gotten down to the booster. I felt if I could just keep it down near the booster we would be all right. Then it looked to me like we were closing rather rapidly. So I thought we were going to get next to it and then we were going to be all right. The reason I felt this was because I could see the two lights. It must have been rotating in such a manner that I could see the two lights. Almost every fifth or tenth time they blinked I could see them. I could see two of them. So I knew by the distance that we were in quite close and everything looked pretty good then. And then for a long, long, long period of

time after that I never saw two lights again. I don't know if you did or not. I kept looking and there was a single light and a single light and a single light, and I didn't know where I was with respect to the booster. And then I started getting the impression without really seeing the double lights, I guess, that it was going away very rapidly. Maybe I did see two lights and I just don't remember it now.

White My impression was that the light was getting fainter.

McDivitt I think that must have been it. I think that must have been it. But all of a sudden I got the impression that it was leaving me at a rapid rate. It wasn't that easy to see. During the few times that the booster was up against the sky background it was easy to see, but when it was down against a ground background, it was very difficult to see. I think it was just before we got to Carnarvon that I felt we were in good shape. And then as we passed Carnarvon, I remember calling I could see the lights of the city. Well, during this period of time all of a sudden I thought it was starting to pull away again. So I started thrusting at it again. And I never really got the double blink of the lights for a long, long, long time. And finally I thought I could see them blinking again, and they were almost a single light this time since they were so far away. And this occurred over a very short period of time. Ten minutes? Five minutes?

White Yes.

McDivitt Is that right? Whatever you think, Ed.

White Yes. I fully agree with you.

McDivitt So then I said to Ed, "I think we are losing it." So I started thrusting at it again. All of a sudden it was apparent that the thing wasn't as close as it had been. So we started thrusting at it.

White In fact, that was one time you said we had lost it, didn't you?

McDivitt I said I think we have lost it. I had it in sight. I didn't say that I had lost sight of it.

White I thought you meant you had lost sight of it.

McDivitt No. I still had it all the time.

White But it wasn't getting any bigger.

McDivitt I didn't have any idea in the world where we were. And I still couldn't really tell. Finally, we could see the sky starting to get a little gray, and I thought at least we were going to get to see where the thing was. And all of a sudden the booster came out just like that, and you could see it. The lights disappeared and there was the booster. It was 2 or 3 miles away, I'll bet.

White You asked me there and I estimated $1\frac{1}{2}$ miles.

McDivitt So, it had gotten that far away in such a short time, and it was down. I think what really gave me the clue that we were losing it again was that I had it on the horizon and it had started going down below us.

White Right. It looked like it was about 30° below --

McDivitt It started going down again. And I could see it was coming down below the horizon, so I knew that I wasn't right with it. But I wasn't really sure how far away I was so I did thrust a couple of times — a foot per second or so — to make sure I always had a closing velocity with it. And finally I got the thing down. It was down so that when it came out it wasn't directly below me; it was out in front of me and down again. And like Ed said, I guess it was down about 30°.

White That's what I'd estimate.

McDivitt When it came out of the night and we saw it out there in the daylight --

White Right. I'd estimate 30° down.

McDivitt It was above the horizon, just barely. Or was it above the horizon?

White No, it was below the horizon. I'd say it wasn't more than 10 or 12° below the earth horizon, but below our local horizon. It was in the neighborhood of 30°. If you looked out level to what you would call level -- but you know the horizon tilts away from you, so --.

McDivitt So here again we were faced with the same kind of problem — to catch up with the booster. What I should have done was to retrofire right then to drop down, get a lower orbit, and come back up. But we had to get to the booster right then or

we weren't going to get to it, because we had the mission to take photographs of it across the States. So I thought if I could close with it at 10 or 15 feet/second we could at least overcome our problem. So I aimed behind it, so to speak, and down, and I thrusted that way trying to get enough closing velocity down and another one that would bring us up to it at the same time; but most of the thrusting I did was down. Then we just didn't gain on it. I started thrusting retrograde with my top thruster, but I was thrusting more back and downward. I just absolutely could not get down to the booster. It kept pulling away and pulling away until the time we got to Hawaii.

White — You were putting a lot of ΔV in there, and we just weren't doing anything. We just weren't making any headway.

McDivitt — It continued to pull away from us and it was falling farther and farther below us until finally --

White — You put in about 40 feet/second to do something with it and it hadn't changed a speck.

McDivitt — By the time we got to Hawaii I told them I thought we were having difficulty doing it. Anyway, I had decided by that time that if we were going to do the mission at all, the only thing we could do would be to leave the booster. The fuel was down to around 75 percent on my gage and the gage kept going up and down, so it wasn't a heck of a lot of help. I had burned around 85 or 90 feet/second. I had numbers in all three of the windows, and of course since I was changing attitudes and thrusting in different directions those numbers were going all over the place. So I made up my mind then that it looked like a hopeless task and that we had better stop this stuff or we were going to lose all the fuel for the whole mission. We probably wouldn't be able to catch it, and we wouldn't be able to do what we were going to do. I think the only thing we could have done to save the whole thing would have been for us just to go forward on the local horizontal and retrograde a large amount on the order of 20 to 30 feet/second, fall down below the thing and catch it an orbit or so later and actually perform rendezvous with it. But because the flight plan was such that we had to get all the EVA done in the first three orbits, and because Chris and I had talked this over and decided the EVA was the more important of the two things, I felt that the best thing to do would be to abandon trying to catch up with the booster.

White Let me interject something else, too. See if you had the same feeling. I had the feeling that the booster orbit had changed so much with respect to our orbit that if we really went down after it, it might jeopardize our lifetime.

McDivitt Honestly, I was concerned about that too, because, remember, I called and asked what the heck our orbit was right then. The booster looked like it was going down at such a rapid rate. By the time we got to the States I would guess it was 5 miles below us at least.

White My impression was even more. I thought maybe it wasn't more at the time but it was going more. I felt that if we really got back with the booster we might have a pretty good orbit, but we would be down in the neighborhood of 130 and this wasn't the altitude we wanted to be, for the 6-day lifetime that we wanted.

McDivitt The other thing that bothered me was that we were going toward perigee where we should have been coming back together. And we weren't. We were pulling away so fast that it wasn't even funny. Frankly, I just couldn't figure out what kind of orbit the booster was in. It looked to me like, if we were having trouble, the place where we should have been the farthest from it was at Carnarvon. Apogee should have been farthest apart. Our perigee should have been closest together. It was almost opposite. We were with it at Carnarvon, but we were far away from it and getting farther away from it as we crossed the United States, or Mexico, or wherever we came. I wasn't looking out at the scenery; I was looking at the booster. It was extremely difficult to track across the water and as we got to the land it was almost an impossibility to track it. Here the distance is extremely difficult to judge. It could have been anywhere from 5 to 15 miles directly below us at this time. If I had a range rate I could have told where I was all the time and with range rate I would have been able to rendezvous with it from a mile. I could have done the things I knew had to be done, rather than try to do it forcefully. I sort of feel the big problem was that we were so optimistic for those first three orbits that it is almost unbelievable. It became apparent when we tried to do the EVA that we couldn't do it in the time allotted. But anyway, I had decided by the time we had gone by Hawaii, or wherever it was after we had been in the daylight for 10 minutes or so, that it was hopeless, and I told that to Ed. I told him I thought we had lost the booster for good. I don't mean I didn't see it but that we weren't going to get back down to it. He agreed with me.

White Yes.

McDivitt I think I could have gotten to the booster in a dignified, normal, slow, easy manner if we didn't have the constraint on us of being next to the booster in the first daylight pass over the States, taking pictures, prepare for the EVA, and be ready to emerge from the spacecraft an hour after we came out of the daylight on our first pass, which was about 2 hours into the flight. I just felt that if I had had more time, I could have gone ahead and done some of this without using brute force to overcome the difference between the booster and myself. I could have gone into a lower orbit and chased it that way. I could have just gone horizontal and retro-fired and fallen away from the thing initially and caught back up with it later on, but it was getting so far away from us to start with that to purposely put yourself farther away from it so that you could catch up later on was not the thing to do. We had to be all done at a certain time. We had to be with the booster when we came back into daylight. That was it; that was the thing. We had to be with the booster, because we had to take those pictures. Then we had to be with the booster again an hour and a half after that, so that we could do the EVA right next to it. And with those kinds of time constraints you don't have time to perform a rendezvous. You've got to get with it right then, but we just couldn't get with it right then.

White You know another thing too; I'm darned glad we didn't use any 10 feet/second initially to separate with. I think we could have used something in the terms of 1 or 2 feet/second, and that would have been fine. Don't you?

McDivitt I cut it short. I only burned about 5 seconds, and I stopped.

White You have been doing that in all your simulations so I knew you were going to do that. You can even cut it less. It was amazing to me the separation you get immediately.

McDivitt It almost seemed like we had a posigrade rocket on the spacecraft and a retrograde rocket on the booster, the way we separated. Well, anyway, we told Guaymas that we had to get resolution immediately if they wanted us to continue to chase the booster, because we had used a lot of fuel, and we weren't getting any closer, and it was still pulling away from us. If they wanted to go for it, they had to make up their minds, and we would really go after it. But I didn't think it was wise. They confirmed this and said, "Knock it off." For

closing rates at rendezvous, I think you could handle 20, 30, or 40 feet/second if you are coming at it, not if you are going away from it. You see we never got a chance to do a rendezvous. We never rendezvoused with it. The best thing we ever did was to get close enough to it where I could at least say I was at the same altitude with it for a change. It was the first time I had gotten back to the same altitude since we left it at insertion. You just can't equate it. You don't do an optical rendezvous with the booster below you. You try to put it above you so you have the stars and the sky background. It was below us. You couldn't do any line of sight nulling, because there wasn't anything to null the line of sight with. On the other hand I found that if the sun was on the window you couldn't see beyond the nose of the spacecraft. This satellite that I saw over around Hawaii -- I saw the thing and we were closing on it. We might have had a better rendezvous with it than with our own booster. We were closing on it, and I was concerned enough that I checked to see where the ac Power Switch was, to see if I had maneuver capability at the time. The sun came across the window and I lost it just like that. It might have been 5 miles out. I don't know. It might have been then. It might have been 50 miles out, but I had the impression in the 30 or 40 seconds I saw it that it was quite close, because I could make out the shape of it. Shoot! The sun came across the window, and that was the last thing I saw out the window. I never saw another thing out the window until we were gone and until the sun finally came off the window. So, if you are doing an optical rendezvous and you've got the sun on the window, I don't know what you'd do.

White And if you have windows as dirty as we had -- our windows had a white film of material on the outside, which made it very difficult to see out when the sun's rays reflected on these particles that were on the outside of the windshield.

McDivitt To just summarize this thing, I think that we came off the booster with a fully unknown relative velocity which was much greater than what we anticipated, and it didn't seem to be an inplane relative velocity. It didn't seem to be an in-plane local horizontal relative velocity. It was out-of-plane, and it looked like the booster headed down with respect to us, because it started separating from us so rapidly. It also had less total velocity. I think that this was the first surprise. It started tumbling, and immediately the rates built up in just a very few minutes to something very high — 40 to 50 degrees/second — but it never got any higher, at least the best we could tell. When we last saw it over Mexico or

over southern United States, it was still tumbling at about the same rate, I guess around 40 or 50 degrees/second. I felt that I got down to it all right, and I was in reasonably good shape prior to Carnarvon, and from that time on until we came out of the darkness I lost it. And I think I lost it because looking at a single light at night doesn't give you any depth perception at all. You just don't know where the booster is. I think that summarizes it. Ed, you want to add anything? You weren't watching it as much as I was, but you saw enough of it to know exactly that was going on.

White Well, you see I wasn't able to put the pieces quite together because I was either looking out, and I couldn't see when you were thrusting, or I was looking in and watching you when you were thrusting and listening and not looking out. I tried to interject my thoughts as we went along and I agree with what you said. I don't believe I want to add anything else.

McDivitt Now that we've covered the tracking and the losing of the booster, I think we ought to go back to the very beginning at insertion, and we will go through the checks that we went through as we proceeded along and the things that Ed and I were both doing aside from tracking the booster, the things that we were either doing to prepare to come back in at area 2-1 or to stay in orbit and proceed with the EVA as we had planned. In looking over the flight plan that we had and the briefing guide on page 6, I have already covered the things on platform alinement. I did not have time to aline the platform. I tried to get it to somewhere near the local horizontal so that in case we had to do a retrofire, I'd be able to do the retrofire. I brought the spacecraft up to a pitch attitude that I hoped was zero, but I never got the spacecraft alined to see that it was zero. So we really went into this thing without my ever having seen a zero pitch attitude on the spacecraft. Obviously I didn't get a chance to see the 30° pitch-down on the retrofire attitude. I didn't really have time to look out the window and do a single thing that would have prepared us to reenter at 2-1 because we were so busy keeping track of --

White You know another thing I'd say also is that we were eternally optimistic. We felt we were going to aline the platform and watch the booster at the same time.

McDivitt As a matter of fact, while I was trying to get the alinement it became apparent to me that I could not aline it. I even thrusted vertically --

McDivitt I was in a horizontal position, and I thrusted down using my top thrusters, so that I would try to keep the booster in my view. Thrusting, chasing the booster, and alining the platform all at the same time — those are the kinds of things you have to do. So, I never did get the platform alined. I did not have time. I got it somewhere near local horizontal. If I was within ±5° in the axis, I think I did a reasonably good job. The Thruster Control Mode Checks that took place at 15 minutes I didn't do as such. I would just throw it into a different mode and thrust. I just did it with a catch-as-catch-can. I did check out the different modes.

White Everything seemed to be working. You weren't getting any thrusters that weren't firing, and your modes all seemed to me to be working properly.

McDivitt It looked pretty good.

White I had one comment on the Communications System Check. Remember we lost good communications with No. 1 UHF, and we switched to No. 2 and seemed to have good communications with it from then on? Now this wasn't representative that we lost UHF No. 1 because we used both of the sets at different times throughout the mission later on. But at this particular time, UHF 1 didn't give us good reception and we switched.

McDivitt I thought communications through the first day of the flight were atrocious. They were terrible. Finally we switched to the Reentry Stub Antenna and that seemed to fix the problem. Didn't you think so? But you know we went back to reentry antenna over Carnarvon one time. We got just as good reception off of it that time as we did any other time.

White I remember when you were making your Communications Check. That was when I was asleep. You were checking the two and you ended up with the reentry antenna.

McDivitt Yes, later on in the flight, as I said, at the end of the first day or so.

White We seemed to get better communications.

McDivitt Communications were better. As a matter of fact, I was a little concerned that the communications were so lousy that we might have to come back in, because we were really losing communications. We were trying HF and all kinds of things. Information just wasn't getting up to us.

White That was after EVA.

McDivitt Right. Communications just weren't getting up to us.

White I figured we didn't have any communications with the ground during EVA.

McDivitt No, we didn't. Our VOX blocked them out.

White I know it.

McDivitt But the Communications Systems Check that was supposed to be performed at 15 minutes -- we sort of already accomplished the thing, because we'd used UHF No. 1 and No. 2.

White I made the check with them.

McDivitt Did you make the check? That's right, you made the check but we didn't use the HF because we weren't going to put the antenna out until after EVA. We didn't do anything with the urine bags except keep them right where they were.

White At this time we didn't pressure check both suits, because we did this later.

McDivitt We didn't aline the platform, as I mentioned. The Control Mode Check was a catch-as-catch-can. You did unstow the equipment that we were supposed to unstow. The blood pressure bulb, the Hasselblad camera and its packs, and a 16-mm camera. During this time when I was chasing the booster, I did manage to get to reach back behind my seat and pull out the bracket for the 16-mm camera. You tracked the booster while I smoothed the thing out.

White That's right.

McDivitt We didn't get out the urine nozzle. How about the utility cord? Did you get out that fancy utility cord, the three-axis utility cord?

White Yes, I knew where it was. I didn't give it to you because you didn't need it.

McDivitt No, I didn't need it. That's right. As Ed said, we did not pressure check our suits at 30 minutes like we were supposed to.

McDivitt There's this little thing here that says measure all ΔV's. All I did was put the computer in Catch-Up, hit the Start Comp button, and just let the numbers fall where they would. At the time that we stopped chasing the booster around, I had about 60 feet/second in one window, 30 in another, and 30 in another. I never really came to a position to try to null all these things out to see what the total ΔV was. I was putting in the thrust with mostly the aft thrusters and the down-firing top thruster. I don't think I used the left and right thruster at all. I don't think I used the bottom thruster at all. There was no difficulty controlling any of them. I used the forward-firing thrusters once or twice to try to slow down, to take out total velocity.

McDivitt Then there was the Accelerometer Bias Check which was another one of those things. I don't know how I let it get into the flight plan.

White We both joked about that one, huh, Mac? We were really going to get an Accelerometer Check when we were trying to track the booster.

McDivitt I was putting ΔV's on the IVI's at a rate of a foot per minute at least. We ended up with over a foot per minute, I think, over that period of time. We couldn't have checked anybody's accelerometer bias, so I just didn't even fool around with it. We were supposed to take a blood pressure. Did you take that blood pressure, Ed?

White Yes.

McDivitt You did take the blood pressure.

White I think I did. I had it out. I don't know whether they asked for it or not.

McDivitt Okay.

White I don't remember on that.

McDivitt Okay. We got the Quantity Read-Off. I guess we got a time hack somewhere in there.

White They called up I believe. I remember them calling the Quantity Read Off, and I turned it OFF.

McDivitt That's right.

McDivitt Then it says at 1 hour we were supposed to unstow and assemble the maneuvering unit in its 16-mm mount. I don't think we had that stuff out by then, did we?

White No.

McDivitt You see, this whole flight plan was based on me being able to track the booster without using any thrust, and essentially having the spacecraft stationary near the booster, without any maneuvering at all, where the station-keeping was a matter of just looking out at the thing and controlling your attitude with pulse. We thought that if the booster was stationary we could get in close to it. We could essentially fly a formation by it with more attitude control than translation control, which left me then free to help Ed assemble all this stuff for the EVA. Well, it turned out that I didn't dare take my eyes off the booster for half a second. So all the things that we were supposed to do together up until the time we finally said goodby to the booster, Ed had to accomplish himself. I was completely unable to help him. The only thing I managed to do was to unstow the 16-mm camera bracket and put the 16-mm camera on.

White I couldn't quite get at that one.

McDivitt No. I could hardly get to it. So we were probably behind at the hour mark. Right?

White Yes.

McDivitt Not by an awful lot.

White I knew we had a problem with the booster, and I was more concerned with our problem with the booster than getting the gun and stuff out then. I felt that they were both tied together and once we lost the booster we didn't have a sweat time-wise on making our EVA. So, I was trying to be of what assistance I could to Jim on watching the booster during these first critical periods.

McDivitt Yes. It wasn't unappreciated because this booster was becoming a speck on the horizon, and if you blinked your eyes you could very well lose the darn thing.

White When we were out that second day, I think you said one time you did lose it for a minute.

McDivitt That's right.

White I was lucky enough to still be seeing it, until you started picking it up again.

McDivitt That's right. So, I'm saying it really took two pairs of eyes constantly looking at that booster to keep it in sight. It's just one of those things that just took so much time that we hadn't planned on. It was almost unbelievable.

McDivitt In our flight plan from an hour to an hour and 20 minutes we don't really show anything, although, here again, we were busy with the booster. So, when we got around to closing with the booster, there wasn't any closing. We finally got clearance over the United States to stop fooling with the booster. I think this was an extremely wise decision.

McDivitt I got to Guaymas, and I said the booster was pulling away from us. We'd already used about 100 ΔV to stay with it, and I recommended that we just give up on it. We had to get a decision immediately, because I couldn't stay with it and not use fuel at the same time. They came back from Texas. I talked to Guaymas and got their confirmation from Texas, which was only a matter of a couple of minutes, saying to leave the booster. That was about the only thing they could say.

4.2 Extravehicular Activity

White And this was the time I went after the gun.

McDivitt Okay. At that time we reverted from station-keeping, which we were both attempting to do, to EVA preparation, which we both had to do. That's when Ed went after the gun, and we started our preparation. We weren't really far behind at this time. All we had to do was get the gun out and get the maneuvering unit. The cameras were already out. You had the Zeiss too, didn't you?

White Yes. The Zeiss came out with the Hasselblad, from the same package as the movie camera. And the storage certainly was a lot easier. What do you think?

McDivitt That's right.

White Particularly getting it out of that center thing. You can just zip them out of there with no problem at all.

McDivitt So, at about 1:30 we started to assemble the gun. If you look at the checklist, you see that we probably got the gun

assembled in nothing flat.

White It's no problem to assemble the gun.

McDivitt We started our egress preparations essentially on time. As a matter of fact, I think we even got started a little earlier.

White Then, we weren't worrying about anything else.

McDivitt Then, we weren't worrying about staying with the booster. We probably started it about 1:35 or 1:40. Over the States we started our egress preparation. We went to our other checklist.

White You were over Ascension, calling off the checklist.

McDivitt I started reading the checklist off to Ed and we went through it. He unstowed everything. Why don't you tell them what you did there, Ed? I just read the checklist off to you, and you went ahead and did it.

White Okay. I had to get back into the right-hand box, and I unstowed the items there. The first time I went back in there, I took the first items out, and I did not unstow the full box. I remember I told you, "It's all coming out, Jim. I'm going to bring them all out on the lanyard." Remember?

McDivitt Right.

White We'd take them off piece by piece if we need it. At that time I pulled the whole lanyard out and the cockpit was full of little bags. I was quite happy that they had prevailed upon me to put a lanyard on all this equipment. I had thought at one time that it would be more desirable not to put a lanyard on. We'd been working a lot in our simulations without the lanyard and it seemed pretty easy. But looking at it now, I highly recommend that everybody keep that stuff on a lanyard.

McDivitt We would have really had a mess if we'd had all those things floating around. It was bad enough as it was.

White Yes, eight or ten of those little bags, and I was glad they were all tied on to one string. I could control them in that manner. They were quite simple to unsnap. I thought the snap attachment made it pretty easy to unstow and selectively pick out the items that I wanted. I unstowed the pouches that I needed, and then we got ready to take the long umbilical out.

I had a little difficulty. It took me about three tries to get it out. It's fairly big package to come through a small hole. It was a good thing that we had taken the velcro off of the batch, because there was no tendency for anything to hang up as we removed it. On the third try I got it out.

McDivitt I thought you did an extremely good job getting the bag out. You got it out a lot quicker than I'd ever seen you do it in the Crew Procedures Trainer in Houston or in the simulator at the Cape.

White You didn't know it. It took me three tries.

McDivitt Well, maybe it did, but it sure looked like it came out a lot easier. I thought you got it out in a big hurry. I didn't notice that it took you three tries. I saw you start, and then just a short time later, it was out.

White Well, it did come out pretty easy, and I think the storage was satisfactory, but I'd certainly recommend that nothing be on the outside to keep it from coming out. It's a real tough --

McDivitt Yes, we need the velcro off of there. We're pretty well sure of that.

White The rest of the equipment — the "Y" connectors, the bag that contained the "Y" connectors, and the attachments for the chest pack I handed to you. I think you were keeping track of most of those things until the time I needed them.

McDivitt Yes, I was.

White The storage of the ventilation module from the floor came off pretty easily. That's when I started going ahead and putting it all on. You read the checklist off to me. I had gone ahead and done a few things anyhow. As you read them off, I checked them off to be sure that I had done them all. I think we had everything out without much problem at all. I think it took us longer actually to put it all together.

McDivitt That's right. It did. We started going through the checklist here and putting the things on, and we started getting more and more rushed. We were supposed to start the Egress Preparation Checklist at about 1:44. We probably started it at about 1:35 or so. We started it about 10 minutes early, roughly, maybe 5 to 10 minutes early. We were supposed to be ready to start the depressurization at 2:30 over Carnarvon.

White I think I could have gone through and hooked everything all up, but I felt that we should go through fairly close to the procedure we had set up on the checklist.

McDivitt That's right.

White I think this slowed us down.

McDivitt Well, we set the procedure up so that when we finished with it, it would be right. I think this helter-skelter thing that we were being forced into was for the birds. So as we got farther along, it became apparent to me that the thing to do would be to stop.

White Right.

McDivitt Go ahead with the assembly of the stuff. Why don't you comment on that?

White I've commented in my Self-Debriefing about the equipment and the assembly of it. I thought there was no difficulty at all in connecting the "Y" connectors, the hoses, and the chest pack. I thought the connection of the chest pack to my harness was a good one. With the velcro I could move it in and out whenever I wanted to so that I could make my connections on the inlet side of the ECS hoses. It went along pretty smoothly, as a matter of fact. I think as we progressed along in it though, we felt that we had everything done. I didn't really feel that we had everything done in a thorough manner. And I think you had that same feeling.

McDivitt That's right. When we got to Kano or Tananarive — I think it was Tananarive — I called whoever I was talking to and said that we were running late and I thought that we would probably not do the EVA on this particular rev. I knew that we had another rev on which we could do it. It looked to me like we had all the stuff hooked up, but we hadn't really had a chance to check it. I also noticed, Ed, that you were getting awfully hot. You were starting to perspire a lot. I didn't like the way you looked to start this whole thing off. So I told them over Tananarive — I believe it was Tananarive — that we would go ahead and continue on, and I would let them know whether or not we were going to depressurize at the next station. We went on ahead and it looked to me like you were all hooked up and about ready to go except for one thing.

White We forgot the thermal gloves. I did not have my thermal gloves on.

McDivitt You did not have the thermal gloves on, which is sort of insignificant, but we hadn't really had a chance to check over the equipment to make sure that it was in the right spot.

White Well, we talked and you said, "What do you think?" We talked it over and I had the same feeling. I thought it sure would be smart if we had about 20 minutes to just sit here real still before we went out.

McDivitt I think we were in a situation where it would probably have gone all right. We had completed about 80 percent of what we really should have had done as far as the checking went, and I just didn't feel that we were in the right shape. Ed didn't think we were, and besides, I could see Ed. He couldn't see himself. Ed looked awfully hot, and he looked like he was getting a little pooped out from playing around with that big suit. I thought that the best thing for his sake, and I knew he wouldn't admit it, was to let him rest up for another orbit.

White I agree that was the best judgment.

McDivitt So, when we got to Carnarvon — I guess it was Carnarvon — I called them and said we were not going to come out on that orbit.

White It was Carnarvon. It was just before we depressurized.

McDivitt So, we postponed it until the next orbit. As a matter of fact, after that we just sat there. We didn't do a thing for about 10 minutes. I let Ed cool off a little bit. We were on two-fan operation at the time. We just sat there and we were cooled off. We went around for about 20 minutes then.

White Okay. Then as we went back around, I asked you to go through the checklist again, and we went through item by item this time.

McDivitt That's right. I might add that we went right back to the beginning checklist, the Egress Preparation Checklist. We started at the top one, and we did every step on it again. We verified every step to make sure we hadn't left anything out.

White We actually went in and checked this time. Another thing we hadn't really positively checked was the position of all the locks on all of the hose inlets and outlets. This time we

actually checked all those locked. All of them were locked in, but it was a good thing to do, I believe.

McDivitt You want to make sure. We did do our Suit Integrity Check before we started all this stuff.

White That's right. We started before we actually went to the unstowing of the stuff from the right-hand aft food box. We went to the Suit Integrity Check.

McDivitt Well, I don't know where it is, but we did it when we were supposed to do it.

McDivitt We did the Suit Integrity check before we started the Egress Preparation Checklist. That's when we did it, over the States.

White I think we did that just about the time you decided to give up on the booster. We did the Suit Integrity Check. Both suits checked out all right. It went up to 8.5 and it leaked down to about 8.5 or something like that.

McDivitt Same thing with mine. It went up to 8.5 and leaked down just a little bit. Not enough to be concerned about.

White No. Oh, one thing that we did do on that extra orbit that we went around -- I disconnected the repress system and we went back on the --

McDivitt Oh, yes. We never even got on the repress system, did we?

White Yes, I believe we were, but then we turned it off. We were all ready to depressurize, and then we went back on the spacecraft ECS system, full, and went through and reverified the whole checklist again. The only things that I would say we hadn't done to my satisfaction the first time was to check the inlet and outlet positions of the locks, and I didn't have my thermal gloves on. It turned out I didn't need them.

McDivitt Also, during this period of time I alined the platform, which was completely misalined. It was probably alined within a couple degrees, but as we went around in Orbit Rate it got farther and farther out of tolerance. So, I managed to aline the platform. Here again, I might comment on the fact that our initial flight plan was so optimistic that it was almost unbelievable. The both of us worked full time on doing nothing except preparing for EVA, and we didn't quite get the job done. I can't believe that we could have possibly flown formation with the booster and taken pictures of it and all the

other things that we had scheduled, and still prepared for this thing and even come close to completing it.

White — Well, the way we would have had to do it, would have been without a checklist. I would have had to just go ahead and hook everything up. I think we could have done it satisfactorily in this manner, but it wouldn't have been the way we would have wanted it.

McDivitt — Yes, that's right. I don't think that's the way it should be done. It was just too bad that we had a time limit on it, but when we did get rid of the booster, or the booster no longer became a part of the flight plan, then the time limit vanished. We found out that we really needed that extra orbit, or probably could have used another 20 minutes.

White — Yes. We went back. And I remember as we came over Carnarvon, we had about a 15 minute chat back and forth — kind of a rest period. We were all hooked up at that time, and that's the time we went on the repress flow, ready for the depressurization. I think they gave us a GO then for our EVA.

McDivitt — That's right. We depressurized the cabin and got down to 2 psi to check our blood pressure. We tried to put our blood pressure plugs in the blood pressure plug port and found out that we didn't have any blood pressure plugs on either suit. This was quite a surprise — an unpleasant one, I might add. Well, we decided that from our past experience and our knowledge of the suit that, even if we did spring a leak in the blood pressure cuff, the size hole that we had in the suit would not be catastrophic, and we decided to go ahead with the EVA.

White — It was within the capability of the system we were using.

McDivitt — At Carnarvon we not only got the go-ahead to start the depressurization, we also got the go-ahead to open up the hatch, the go-ahead that we weren't supposed to get until Hawaii. So, we went ahead and did that.

White — Yes. I'm kind of curious of the whole time. We were out nearly an orbit, I think. We didn't get it closed back again till we got back around to Carnarvon.

McDivitt — We were in a whole orbit depressurized.

White — Yes, I don't think people quite realize that.

McDivitt We'll remind them. As we got to the hatch opening thing, we had our first difficulties with the hatch. The gain gear, I guess you want to call it -- actually I call it the ratchet -- didn't want to engage into the UNLOCK position. We fooled with it a few times and it finally engaged in the UNLOCK position, and Ed was able to go ahead and start.

White The first indication of trouble was when I unstowed the handle to open the hatch. The handle freely moved up and down with no tension on it at all. I knew right away where the trouble was. It was up in that little spring on the gain pawl. So, I went up and manipulated it back and forth in hopes that I could break the lubrication loose in the spring to get it to work. We must have spent several minutes with the hatch. I thought perhaps it might have been stuck in the manner that the hatch got stuck in the Wet Mock, where it just was stuck. You could ratchet it open, but the hatch itself wouldn't open. It was pretty apparent the trouble was in the gain pawl. I jimmied it back and forth, and then I decided to go ahead and try the technique of actuating it in sequence with the hatch handle. If you actually replaced the operation of the spring with mechanically moving the gain pawl up and down, you can do the same work that the spring does.

McDivitt Your fingers sort of take the place of the spring and drive this little pawl home.

White This is the first time we actually tried this in a suit. It requires you to press up with your left arm to get at the gain pawl, and at the same time to hold yourself down. And I think later on this was a source of some of our problems which I brought out now so that we can find out later on. I felt it start to engage and start to ratchet the lugs out. Jim also verified that they were coming open. I backed them off, and I remember Jim saying "Ooop! Not so fast!" and at that time it popped. The hatch actually popped open, jumped open about 3 or 4 inches.

McDivitt I was expecting the hatch to come open with a bang. Although we had the cabin to vent and it had bled on down to where there was nothing indicated on the Cabin Pressure Gage, we still really had the repress valve on. He was bleeding right into the spacecraft. We never got down to a vacuum and, even though we had a cabin pressure of only a tenth of a psi, we spread it over the entire area of that hatch, and that puts a pretty good size force on it. I had a real tight hold on

the hatch closing device, and when it popped open I was able to snub it.

White — It didn't really open with much force, did it?

McDivitt — Well, it did. It opened with a fair amount. It popped and I couldn't stop it the first inch or so. Then, of course, as soon as it opened, that much pressure died off. I just sort of snubbed the thing to keep it from flying all the way open. Now if I hadn't been holding onto it, I don't think it would have gone open more than 2 or 3 feet.

White — This is another point too. There's more force on the hatch actuator than I thought. I didn't just flip the door open with my hand. I had to actually forcibly push it open, similar to the force with which I opened the hatch lying on my back under 1-g. That's about the force that I had to on the hatch to open it.

McDivitt — This extra force that we are talking about is due to the O-rings they put in the pyros that are used for jettisoning the hatch. This is something that they put in just before the flight -- something that we'd gone out to the spacecraft to feel. We knew just about what the force was, but it was pretty high.

White — Okay. At this time I had certain things that I had to accomplish. I had to mount the camera on the back of the adapter and mount the umbilical guard on the edge of the door. I elected, as I had planned, to go ahead and mount the camera first and then the umbilical guard. I mounted the camera and it went on without too much difficulty. The three little lugs on the bottom are a good mounting scheme. I think I would make a little easier engaging device for working out in a hard suit. I had familiarity with it, and it did lock up there all right. The umbilical guard for the umbilical on the side of the door took me a little longer to mount. Back to opening the hatch -- I had the thermal gloves on when we were opening the hatch, and because of the fine work I had to do with the little gain and the drive lugs up there. I had to remove the thermal gloves so that I could actually actuate those small levers. I couldn't do them with any precision with my gloved hand. So, I took the thermal gloves off at this time, and I handed them to Jim. When I got back out, I didn't notice any temperature extremes. I felt quite confident that there wouldn't be any heat, since we just came out of the dark side, so I decided to do the actual work in putting this equipment on with my plain pressure suit gloves.

I had much more feel with them. Let me get back now to the umbilical guard on the door. It went on pretty well. It took me a little longer and it took me four or five tries to get the little pin into the hole that actually snubbed the guard down on the door. I did something then that I hadn't planned to do. The bag floated up and out of the spacecraft and now it was above the point where the hose was going through the umbilical guard. I had planned to keep it down inside. I left it there for two reasons: (1) I figured it was there already and I would have had to take the umbilical cord off again and scooted it back down, and (2) I also felt that Jim might have had a better view if it wasn't sitting right in front of him on the hose coming up from the repress valve. I elected to go ahead and leave the bag there. I then reported to Jim that I had everything all mounted and was ready to go. I had planned to take a short series of pictures. Since we had gotten out early, I had a little extra time at this time, so I went ahead and turned the outside EVA camera on. I took a short sequence of pictures that actually gives the egress up out of the seat. I kind of went back down and came out again so they would get an actual picture of it, and then I turned the camera off again. I mounted the camera and I turned it on while it was on the mount. I took a short sequence when I asked Jim to hand me my left thermal glove, which he did. I put the thermal glove on while the camera was running. I turned back around. I wanted to be sure the camera was off, so I took it off the mount, and I turned the camera off and actually visually took a look to see if the switch was off.

McDivitt Did you knock it off one time? I thought you said the camera fell off.

White By golly, I did. So I must have mounted it four times. That's right. I knocked it off one time during this time when I was out there. I got the picture of the egress, and then I asked you to hand me the gun. At this time the camera wasn't running. I had the glove on my left hand, and I went ahead and took the gun and made sure that it was ready to go. I had the camera on at that time and the valve was on. I checked the valve to be sure it was on and I was essentially ready to go. I don't know how long this took, but it took me longer than I thought. We had had early egress and it wasn't too much before I got the GO that I was ready to leave the spacecraft.

McDivitt I'm not sure whether we got that GO from Hawaii or Guaymas. I sort of suspect that we got that GO from Hawaii, not Guaymas as we had originally planned.

White Well, it sure seemed short from the time I was mounting all that stuff out there to the time you told me to go.

McDivitt That's right. I'm sure we were talking to Hawaii, and they said you're clear to proceed with EVA.

White And that's when I went. I bet we went out at Hawaii.

McDivitt I think we went out at Hawaii.

White I delayed from the time you gave just a minute, long enough to actuate the camera on the outside. This was kind of interesting. When I actuated that camera, I had my gun tied to my arm with the tether. It floated freely to my right. I turned back around and turned the switch ON on the camera, and listened and made sure the thing was running. I knew it was running, and put it down. I think you'll see this on the film. I wanted to be sure it was running when I mounted it back there. I actually took it off and turned it on, and I remember it jiggling up and down when I was trying to stick it on there. It ought to be a funny looking film. And it might even show the gun floating beside me as I was mounting it. That's when you said, "Slow down. You're getting awfully hot." I was working pretty hard to get that on. I mounted the camera again, and this is where I tried to actually maneuver right out of the spacecraft. I knew right away as soon as I got up -- I felt even before -- that the technique of holding on to the bar in the spacecraft and sticking a finger in the RCS thruster wasn't going to work. I mentioned that to Jim before -- that I didn't think I would be able to do it.

McDivitt I think you and I both knew how you were going to do, and everybody else was planning for us how we were going to do it, but without any real experience in it. People who didn't know a lot about it were planning this sequence, and it wasn't the way it should have been.

White I couldn't have done that. I didn't have three hands. I couldn't hold the gun and put a finger in the RCS nozzle, and hold the handle at the same time. I thought it would be more desirable anyhow to actually depart the spacecraft with no velocity, other than that imparted by the gun. This is exactly what I did. I thought that I was free of the spacecraft, and I fired the gun. I realized that my legs were still

dragging a little bit on the side of the seat, so I pulled myself out until I could see that my feet were actually out of the spacecraft. I think you called me and said I was out of the spacecraft.

McDivitt I called and told you that you were clear. That's right.

White And that's when I started firing the gun and actually propelled myself under the influence of the gun. I don't believe I gave any input into the spacecraft when I left that time, did I?

McDivitt No, you left as clean as a whistle.

White Later on, I gave you some pretty big ones.

McDivitt You were really bouncing around then.

White Now at the time, I left entirely under the influence of the gun, and it carried me right straight out, a little higher than I wanted to go. I wanted to maneuver over to your side, but I maneuvered out of the spacecraft and forward and perhaps a little higher than I wanted to be. When I got out to what I estimate as probably one-half or two-thirds the way out on the tether, I was out past the nose of the spacecraft. I started a yaw to the left with the gun and that's when I reported that the gun really worked quite well. I believe that I stopped that yaw, and I started translating back toward the spacecraft. It was either on this translation or the one following this that I got into a bit of a combination of pitch, roll, and yaw together. I felt that I could have corrected it, but I knew that it would have taken more fuel than I had wanted to expend with the gun, so I gave a little tug on the tether and came back in. This is the first experience I had with tether dynamics and it brought me right back to where I did not want to be. It brought me right back on the top of the spacecraft, by the adapter section. Jim was calling me and said that I was out of his sight. I told him that I was all right, that I was up above the spacecraft, I looked down and I could see attitude thrusters firing, little white puffs out of each one. I wasn't very close. They looked just like what Chamberlain's report told us. It looked just like about a foot and a half or maybe 2 feet of plume from the spacecraft and certainly didn't look ominous to me at all. In fact it looked kind of like the spacecraft was really alive and working down there. I knew Jim was doing his job holding attitude for me.

McDivitt Let me comment on the attitude-holding right now. Initially we started out in blunt-end-forward, banked to the left about 30° or so. This happened to be the attitude we were in. We wanted to be blunt-end-forward for the sun, and they told me it didn't make any difference what attitude that we were in when we opened up the hatch. We had originally planned on opening the hatch toward the ground. I was called by some station that said it didn't make any difference what attitude I was in when I opened the hatch. We opened the hatch. We opened it in that particular attitude, and I held the attitude for the first portion of the time that Ed was out. When you had the gun you managed to stay reasonably well out in front. I held the spacecraft essentially stationary with respect to the local horizontal. After you ran out of fuel in the gun you were on top of the spacecraft all of the time. I felt that unless you really had to have the thing stabilized, to maintain your sense of balance or whatever you want to call it, I wouldn't fire the thrusters.

White You asked that already when I was out.

McDivitt Yes. I asked you if you needed it and you said no. So, then I felt it would be better not to fire the thrusters, because you were drifting back up over the cockpit. I could see that you were going up over us. I couldn't see back behind me, but I could see by the motions that you had when you went by me that you were going to continue on. I felt that it would be a lot safer if we just let the spacecraft drift unless it got into very high rates. I fired the jets a couple of times just to knock off the rates. I let it start drifting when you got on the tether so that you wouldn't get back there on top of one of those thrusters when I fired them. From about the time you ran out of fuel until you got back in I didn't do much attitude controlling. I did some. Everytime the rates got up pretty high, I'd knock them off. You were able to maneuver around the spacecraft when the spacecraft itself had rates of say ±2 degrees/second in a couple of the axes at the same time. Here again before the flight we discussed the axis system. Ed selected the spacecraft as his axis system. It didn't appear that he was having a bit of trouble with it. He was maneuvering with respect to it, regardless of what the earth, sun, moon, and stars were doing. It was pretty obvious to me that was exactly what he was doing.

White Well, when I came back the first time to the spacecraft with the gun -- I had used the tether to bring me back -- I did go back up on the adapter area. This is the first time it had happened. I said, "All right. I'm coming back out again."

This is one of the most impressive uses of the gun that I had. I started back out with that gun, and I decided that I would fire a pretty good burst too. I started back out with that gun, and I literally flew with the gun right down along the edge of the spacecraft, right out to the front of the nose, and out past the end of the nose. I then actually stopped myself with the gun. That was easier than I thought. I must have been fairly fortunate, because I must have fired it right through my CG. I stopped out there and, if my memory serves me right, this is where I tried a couple of yaw maneuvers. I tried a couple of yaw and a couple of pitch maneuvers, and then I started firing the gun to come back in. I think this was the time that the gun ran out. And I was actually able to stop myself with it out there that second time too. The longest firing time that I put on the gun was the one that I used to start over the doors up by the adapter section. I started back out then. I probably fired it for 1 second burst or something like that. I used small burst all the time. You could put a little burst in and the response was tremendous. You could start a slow yaw or a slow pitch. It seemed to be a rather efficient way to operate. I would have liked to have had a 3-foot bottle out there — the bigger the better. It was quite easy to control. I feel that with the gun there would be no difficulty in maneuvering back to the aft end of the spacecraft, and this was exactly what I did later on. Just on the tether. I got all the way back. So, I ran out of air with the gun, and I reported this to Jim. I didn't attempt to take any pictures while I was actually maneuvering with the gun. The technique that I used with the gun was the technique that we developed on the air-bearing platform. I kept my left hand out to the side, and the gun as close to my center of gravity as I could. I think that the training I had on the air-bearing tables was very representative, especially in yaw and pitch. I felt quite confident with the gun in yaw and pitch, but I felt a little less confident in roll. I felt that I would have to use too much of my fuel. I felt that it would be a little more difficult to control and I didn't want to use my fuel to take out my roll combination with the yaw. We divided our plan so that I would have a part of it on the maneuver and a part of it on the tether. I don't know how far along we were when the gun ran out.

McDivitt Right on schedule when the gun ran out. We planned 4 minutes for the gun portion of it. We were just about on schedule.

White I bet we used a little more than 4, because I think we came out earlier than we thought.

McDivitt No, I started the event timer to time it.

White Well, this is where my control difficulty began. As soon as my gun ran out I wasn't able to control myself the way I could with the gun. With that gun, I could decide to go to a part of a spacecraft and very confidently go. I think right now that I wish that I had given Jim the gun and taken the camera off. Now I was working on taking some pictures and working on the tether dynamics. I immediately realized what was wrong. I realized that our tether was mounted on a plane oblique to the angle in which I wanted to translate. I remember from our air-bearing work that everytime you got at an angle from the perpendicular where your tether was mounted, it gave you a nice arching trajectory back in the opposite direction. You're actually like a weight on the end of a string. If you push out in one direction and you're at an angle from the perpendicular, when you reach the end of a tether, it neatly sends you in a long arc back in the opposite direction. Each time this arc carried me right back to the top of the adapter, to the top of the spacecraft, in fact, toward the adapter section. One time I was so close to the thrusters back there that I called Jim. I said, "Don't fire any more", because I was right on the thrusters. I was even closer than that foot and a half which I noted to be the length of the thruster plumes, and I didn't want to sit on a firing thruster.

White We were discussing the EVA and I was saying that I spent approximately 70 percent of my time, it seemed, trying to get out of the area back above the spacecraft in the adapter area.

McDivitt Yes, you intended to go toward the position that was directly over the cockpit. You always arced past it because you were coming from the front.

White This was exactly right because that's exactly where my tether was connected. Chris had been very emphatic that he wanted me to stay out of this area, and I had agreed to stay out of there. I tell you, I was doing my level best to keep out, but the tether dynamics just put me back there all the time.

McDivitt Let me interject something here. When we were talking about the control modes and how we were going to control the spacecraft, we decided on the Pulse Mode rather than the Horizon Scan Mode, or anything like that. The Horizon Scan Mode would leave me free to use both hands to take pictures of you, and that way I wouldn't have had to control the spacecraft. But since it was an automatic mode and it fired whenever it felt

like firing, it didn't give us any flexibility, and this is why I felt that the best mode to be in was Pulse, in case you did get back there.

White That's exactly what happened.

McDivitt I didn't have to worry about the thruster going off in your face. I didn't want the thrusters to fire, and they didn't fire because I didn't touch them. It was a wise choice.

White I think this was good. When you look at it from a picture-taking viewpoint, it gave a wider spectrum of pictures. You got different views of the earth and the horizon. I'm glad we weren't held to a specific mode.

McDivitt I think that the picture we did take or the attitude that we started out, which is shown in the newspaper, is just about right.

McDivitt I guess we banked over to the right, I don't know.

White That must have been just as I came out.

McDivitt I don't remember, but it had enough of the ground in the background so that it was certainly worthwhile.

White On one of my passes back to the adapter area I got so far back that I was about 3 or 4 feet from the adapter separation plane, perpendicular to it. It was rather jagged. There did appear to be some sharp edges, but it really didn't look very imposing to me. I took a picture of it. That's one picture I believe was good and should come out.

McDivitt The trouble is it was probably set on infinity and you were up about 5 feet.

White No, I set the camera to about 15 feet or so. It might be a little fuzzy because it was too close.

White No, I didn't see the far side of the adapter. It didn't go all the way around. I think I could have pushed off and gotten back that far.

McDivitt No. Better to stay away from it.

White Well, I felt that if I got going I could have swung all the way around and had my umbilical right on the edge, without anything to hold on to or any gun to control myself. This

didn't seem like it was at all safe, and I had told Chris that I wouldn't go behind the craft. So I didn't go back there.

McDivitt That must have been just about the time I told you to come back in.

White No, I would estimate this was about two-thirds of the way, and about this time I was after pictures. I knew that was a part of the flight plan that I had, in my mind, fulfilled satisfactorily. So I tried to get some pictures, and this is where I really imparted some velocities, trying to get away from the spacecraft into a position so I could take a picture. I went out to the end of my tether cord quite a few times doing this. I seemed like every time I would be completely 180° to the spacecraft. I'd have beautiful views of the ground but I couldn't see the spacecraft. It was a definite mistake to mount the camera on the gun. That made it very difficult to use the camera. I had to point not only the camera but the gun with the long thrusters mounted out on the little arms. I'd want to take a picture of an object like the spacecraft, and there were too many loose items to get tangled up in and block the camera. I know my tie-down strap was floating loose. I had left that out intentionally so that I could get it later on any time I had to pull my helmet down. Occasionally when I got in close to the spacecraft, the bag and strings associated with the bag were tangling up around the vicinity of the gun and the camera. And it seemed like the umbilical was right in front of the camera all the time. So, I think the pictures will verify that I was flicking my right arm quite a bit in the later part of the flight, trying to clear things out from in front of it to get a picture. Whenever I was in a position to get a picture it seemed like I was facing away from the spacecraft. I took a couple of shots in desperation, and I think I might have gotten a piece of the spacecraft. But I never got the picture that I was after. I wanted to get a picture of Jim sitting in that spacecraft, through the open hatch, with the whole spacecraft. I know that I didn't get that. In fact, as time went on I realized that I wasn't going to get much of a picture. I was trying everything I knew to get out there and get stabilized so that I could turn around and get a good picture. I just couldn't do this. This was at the time when I was looking a little into the tether dynamics, and I actually kicked off from the spacecraft pretty hard. I remember Jim saying, "Hey, you're imparting 2 degrees/second rotational velocity to the spacecraft when you depart." I was pushing the spacecraft

quite vigorously. I wanted to push off at an angle of about 30 or 40° to the surface of the spacecraft. And any time I pushed off from the surface of the spacecraft, my main velocity was perpendicular to the surface. It shot me straight out perpendicular to where the tether was attached. Again, this wasn't in the position that Jim could take a picture of me, and it wasn't too good a position for myself. I usually ended up facing away from the spacecraft.

McDivitt Let me interject something here. In desperation I took the Hasselblad camera and stuck it over out through Ed's open hatch, and asked him if he could see the camera and if he could tell me which way to point it. He couldn't see the camera so he never really did tell me which way to point it.

White No. This was the time that you said, "Hey, get in front of my window." It just so happened that I was right up close to the spacecraft and that's when I came over. Do you remember me coming over and actually looking about a foot from your window, Jim?

McDivitt Yes.

White Looking right at you.

McDivitt Yes, I think that was the time the movie camera wasn't going and I was fooling around with it, trying to make sure that it was running.

White Oh, that would have been a very interesting picture.

McDivitt I'm not sure it was going, Ed, because, as you know, we had so much trouble making the left-hand one run. We had that trouble throughout the remainder of the flight. You pushed a switch over and it seemed to run sometimes, but sometimes it wouldn't. I kept worrying about whether or not it was running so I would grab a hold of it to see if I could feel it clicking over. I switched the ON-OFF switch on a couple of times to make sure I could tell the change in the feel of it. I'm afraid this time is one of the times that I didn't have the camera going, because I was trying to make sure that it was going. I'm not positive. I hope I got the picture, but I'm not sure about it.

White That was the time that I came right in, and I couldn't have been more than a foot from your window, looking in. I could actually see you sitting there.

McDivitt That's probably when you put a mark on my window.

White I think the way I did that -- I could actually see you in there and I pushed away with my hands a little bit. I think this was the time that either my arm or my shoulder contacted the upper part of your window, and you called me a "dirty dog" because I had messed your window up. You know, as you look back in retrospect, I wish you'd handed me a kleenex and I wish I'd cleaned up the outside of those two windows. I think we could have done it.

McDivitt Yes. We'd have never gotten to the kleenex at that time, but I think we might have done something about it.

White I think I might have, but we might have smeared them so irreparably that it might have --.

McDivitt That's right. When you looked at that window of mine from the inside while the sun was shining, it looked like it was a black paint smear, such as if you'd take a piece of white linoleum and a black rubber soled shoe and made a mark on the linoleum. It had that kind of consistency. It was absolutely opaque. Just as black as it could be.

White Yes, I could tell. When I hit it I could see from the outside that it turned white.

McDivitt It turned black from the inside.

White From the outside it was white.

McDivitt From the inside it was black. When I got the thing turned around a different way with the sun on it, it was perfectly clear as if you had taken the coating off, and what I was seeing was through a perfectly clear surface. So, I don't know really whether the thing was black, that you placed something on the window that would make it black, or whether you'd taken something off that was very white, very thin.

White I smeared the film that was on your window. I'm quite confident that is what happened.

McDivitt I looked at our spacecraft windows after they got it onboard, and I could still see that little hunk of window. It looks to me like what you did was remove a layer off the window, rather than put something on it. You took something off it. Except I can't possibly imagine why it was so black and opaque with the sun shining on it at certain angles.

White I'd like to comment on the ease of operation outside on a tether. If you've ever tried to hang on the outside of a water tower, or about an 8-foot diameter tree, you can visualize the problem I had out there. The decision to leave the hatch open was probably one of the very best that we made. I had nothing outside the spacecraft to stabilize myself on. There just isn't anything to hold onto. I think Jim will remember one time when I tried to hook my fingers in the RCS thrusters. I think Jim could see because --.

McDivitt I could see.

White I was right out in front of Jim's window. This gave me really nothing particularly to hold onto. It didn't stabilize me at all. I had nothing really to hold onto, and so if you have ever tried to grasp an 8-foot diameter tree and shinny up it, you know the kind of feeling that I had outside there. There just wasn't anything for me to hold onto. One thing though that I'll say very emphatically -- there wasn't any tendency to recontact the spacecraft in anything but very gentle contacts. I made some quite interesting contacts. I made one that I recall on the bottomside of the right door in which I had kind of rolled around. I actually contacted the bottom of the spacecraft with my back and the back of my head. I was faced away from the spacecraft, and I just drifted right up against it and just very lightly contacted it. I rebounded off. As long as the pushoffs are slow, there just isn't any tendency to get in an uncontrollable attitude.

McDivitt It seemed Ed did hit it pretty hard at one time. I think that was after he pushed off violently; he went out and it seemed he came back and bashed it pretty hard. I remember a pretty solid thump. It seemed it was over the right-hand hatch or just right behind -- .

White I know a couple of times I kicked off with my feet, and I think I know the time you are talking about. I came in with my foot. It wasn't so much the contact with myself --.

McDivitt What did you do? Contact and push off?

White I contacted and pushed with my foot.

McDivitt I heard a big thump and I think I called you at this time to take it easy.

White I believe that was on the front end of the R and R Section on my side where you couldn't see me.

McDivitt It was a position that I couldn't see.

White One of the pictures that I saw last night in the movies, I think, was made at that time. I was coming in fairly rapidly and I wanted to get back out, so I kicked off again with my foot fairly hard. It was a very good kick. I felt that I certainly could have controlled myself without the gun out there if I had just some type of very insignificant hand-holds or something that I could have held onto. I believe that I could have gone on back to the adapters with a minimum of several hand-holds to go back there, going from one to the other. I was actually looking for some type of hand-holds out there. I remember that the only one that I saw was the stub antenna on the nose of the spacecraft. I could see the ceramic covering over it, I believe it was ceramic, or some kind of covering over it.

McDivitt Yes, it's white.

White I felt that this wasn't quite the thing to grab onto; this was at the time when I wanted to get out at about 10 or 12 feet directly in front of the spacecraft. I certainly had the urge to hang onto the antenna and push myself out. But I didn't and there really wasn't anything to hold onto. You really need something to stabilize yourself. I worked around the open hatch.

McDivitt Let me ask you a question. How about putting the hand-hold inside the nose cone? A fairing is up there for launch, just the fairing. We could mount a hand-hold right inside.

White I think we could have really made some money if we had had an attachment for the tether out there right on the nose of the spacecraft.

McDivitt Strung the tether out there and then attached there?

White Right. Have a second attach point and put it right out there. It would give you something to hold onto out there.

McDivitt Yes.

White There wasn't anything to hold onto on the R and R Section.

McDivitt I know it.

White It had smooth corners and the only thing I could have grabbed was the antenna, and I didn't want to grasp that. We thought

one time of holding on out there and thrusting, but --.

McDivitt There isn't anything to hold onto. I think you probably could have gotten a hold on the antenna and held onto it without hurting it. I examined it pretty closely before the launch, and it looked pretty sturdy.

White I thought this was something we needed and I didn't want to fool with it.

McDivitt As it turned out we finally needed that antenna because that was the antenna that we used the whole flight — that stub antenna in the nose.

White Yes.

McDivitt When we opened up the spacecraft the hatch came open with a bang. The air that we had inside was obviously of greater pressure than that outside, and we had a great outflow of things including a piece of foam that we had used to pack our maneuvering gun in its box. It was the first thing that we put in orbit. But then throughout the time that Ed was out, he wanted the door wide open. It was pretty obvious that the flow was from the spacecraft to the outside because part-way through his maneuvers his glove floated out and floated away from the spacecraft with a reasonably good relative velocity. The entire time he was out, even after we had the hatch open for 20 to 25 minutes, we were still getting particles floating out through the hatch. It was the flow. The streamlines were very obvious. It was from inside the spacecraft to the outside. I guess the spacecraft was out-gassing at a sufficient rate to cause a reasonably large pressure differential from inside to outside, and it was certainly relieving itself. I noticed this even as we were trying to get the hatch closed. There was still a flow from inside to outside.

White Okay. I think that pretty well covers most of the things that we actually did while I was out there.

McDivitt Now, as for getting back in --.

White Yes, let's go all the way back through and come back in. The time really did go fast! I had watches with me, but I didn't look at them.

McDivitt I was watching the time. I noticed my watch around 4 minutes, 6 minutes, and 8 minutes. And then you got involved in

floating around as we were trying to get that last picture.

White The time really flew!

McDivitt You kept getting behind me all the time and I became distracted from the time we were on VOX, completely blocking out the ground. Our VOX must have been triggered constantly, because whenever we were on it they couldn't transmit to us.

White That's where the time got away from me.

McDivitt That's right, and it was 15 minutes and 40 seconds when I looked at my clock. So, I thought that I had better go to the ground. I said to the ground, "Do you have any message for us?" because I knew it was time to get back in. And they just said, "Yes. Get back in!"

White Right. I remember hearing Gus say, "Yes, get him back in!"

McDivitt This is what all the fuss was about. They might have been transmitting to us to get back in but we were on VOX and couldn't hear a thing.

White I did a few things after this time that I wasn't doing to deliberately stay out. But I was deliberately trying to do one last thing. I was trying to get that last picture. And this was one of a couple of times that I kicked off the spacecraft really hard, to get out to the end of the tether. And I wasn't successful in getting the position so that I could get a picture. I felt this was the one part of the mission that I hadn't completed. Everything else was successful and I wanted very badly to get that picture from outside. I spent a moment or so doing this. This was also the period of time in which I called down to Jim and said, "I'm actually walking on top of the spacecraft." I took the tether held onto it, and used it as a device to pull me down to the spacecraft. I walked from about where the angle starts to break between the nose section and the cabin section. I walked from there probably about two-thirds of the way up the cabin, and it was really quite strenuous. Could you see me walking along, Jim?

McDivitt No, I couldn't see but I could feel the thumping on the outside.

White That's when I got to laughing so hard. This was when Jim was saying to come in.

McDivitt Yes, I think this is when I got a little stern and said, "Get in here!"

White When I was walking on the top and was laughing, Jim probably didn't think I thought he was serious. But it was a very funny sensation. Now as far as delaying, there were certain things that I had to do before I came in. And there wasn't anything in the world that was going to hurry me up in doing them. We had just agreed that we'd do things in a slow manner and this is the way we'd do it.

McDivitt Let me talk about the time here. It is implied in the papers that Ed didn't really want to come back in, and didn't. I think one of the things is that we didn't hear. We didn't have any transmissions from the ground after he stepped outside until I went off VOX at 15:40. They said, "Come back in!", and I told him to come back in. I think that he probably delayed about a minute or 2 minutes.

White I think so, trying to get the pictures.

McDivitt And at that time I got a little irritated and hollered at Ed, too. Then he started back in.

White But when I came back I had things to do.

McDivitt Yes. I know it. That's what I'm trying to say to get this thing in its proper perspective.

White Yes.

McDivitt We were 3 minutes 40 seconds late getting started back in because we just lost track of the time. I couldn't see Ed any longer. I was trying to keep track of what he was doing without being able to see, and I lost track of time. Then I think he delayed probably a minute or a minute and a half before he started back in.

White That's right.

McDivitt So, those are the two delays. We'd agreed on that he'd start back in after 12 minutes. From then on all the time was spent just trying to get back in.

White I had certain things to do. I had to disassemble the camera that was on the spacecraft. I did this very slowly. I had to disconnect the electrical connection to it and hand the camera back in to Jim. Then I had to go out and disconnect

the umbilical, and this really went pretty well. The little tether that I had them put on the ring, a pull ring, to disconnect the pin worked pretty well. I disconnected the umbilical and discarded the umbilical cord.

McDivitt That was the last thing Ed put into orbit.

White Right. I put that in orbit. Earlier, it was really quite a sensation to see the glove floating off. I asked Jim a few minutes before about the glove, or Jim had asked me, "Hey, do you want this other glove?" About a minute later, I saw it go floating out of the hatch.

McDivitt All I can say, Ed, was about a half hour later I was sure thankful that we had gotten rid of something. We had so much other junk that we didn't want.

White I saw the glove come floating out of the right-hand hatch, and it was a perfectly clear picture of the glove as it floated out. It floated out over my right shoulder and out -- it looked like it was on a definite trajectory going somewhere. I don't know where it was going. It floated very smartly out of the spacecraft and out into space.

McDivitt I think this had a lot to do with that out-gassing. There was a definite stream --.

White Yes. It was following the streamline right out of the spacecraft.

McDivitt It went out perpendicular to the spacecraft, whichever direction that is.

White Back to getting back in the spacecraft — I had the one thermal glove on the one hand, my left hand. I always wanted my right hand to be free to operate that gun and the camera. The way the camera was mounted on there, I had to use both hands — one hand to actually stabilize it with the gun and the other hand to reach over. Again, I think dynamics played a little bit of a role there. Everytime I brought my hand in from a position out on my left, it tended to turn me a little bit, which is exactly what we found happened on the air-bearing tables. I think that the camera should have been velcroed to my body somewhere and used independently of the gun.

McDivitt Yes. I got the same impression. I got the impression that what you really should have done was --.

White Dropped the gun.

McDivitt Unhooked the camera out there floating around and just thrown the gun away. I don't think you ever should have tried to bring it back.

White Well, what I should have done was fold the gun and handed it to you.

McDivitt That would have taken longer. It would have taken precious seconds out of the very few that we had anyway. I think you should have just unhooked it and thrown the gun away.

White This was probably the thing that I was most irritated with not completing. I didn't feel the pictures were satisfactory with the camera outside. But I think the reason was that my camera was not in a position so I could use it adequately. But coming back in was the last thing. As a matter of fact, before I dismounted the movie camera and dismounted the umbilical, I folded the gun.

White I took the lanyard off with the camera on it, and handed Jim the gun and the camera.

McDivitt And I stuck it down between my legs.

White That was the first thing that I handed in. Then I handed in the 16-mm camera, and then I threw away the umbilical. This was where the fun started. I found it was a lot more difficult coming back in than I had remembered in the zero-g training. It seemed like I was contacting both sides of the hatch at the same time, much firmer than I had in the zero-g airplane.

McDivitt You mean you were hitting the hatch on one side and the hatch opening on the other side.

White Coming back in, I was contacting the side of the spacecraft on both sides.

McDivitt Yes, that's right.

McDivitt You weren't really hitting the hatch on both sides; you were hitting the hatch opening on both sides.

White Yes. I was coming down through there. I felt a much firmer attachment wedging in there than I'd remembered from the zero-g training. I think this might be associated with the extra

7/10 or 8/10 pound of pressurization on the suit. I just might have been a little fatter. I did notice that the suit was a little harder. I felt this type of suit before during my pre-work, so this wasn't a surprise to me at all. But I did feel like I was a little fatter getting in and wedged a little tighter.

McDivitt I really don't think Ed was any fatter. I think that link in the suit holds the suit to whatever volume it's going to go to. And I don't think a couple psi are going --.

White Well, I felt like I was hitting a little more as I came in.

McDivitt Yes. I think what happened was he was stiffer, and he wasn't bending his legs and his arms any.

White You mean with the harder suit I was stiffer?

McDivitt Harder. And your arms were stiffer and you weren't bending them around as much. It looked a lot more rigid.

White This might have been.

McDivitt Not semi-rigid -- Ed was rigid.

White All right. This might have been.

McDivitt And that looked to me like it might have been the problem.

White This might have been part of the recontact on the side of the spacecraft that I noticed. But as I came back in, I noticed that I had to work a little harder, and I hoped the tape was running because I think we had a very good commentary. We were both talking very clearly back and forth to each other during this time, and I was telling Jim that I was going to come in slow because it was a little tougher than I had thought. We were talking back and forth about being slow and taking it easy.

McDivitt I actually helped push Ed down in there. I don't know whether he felt it or not in that suit.

White No, I couldn't.

McDivitt I reached over and I steered his legs down in, and I sort of got him settled in the seat a little better than what he was getting himself.

White Yes. Right. I was kind of free wheeling my feet up there.

McDivitt Yes. It looked to me like Ed was holding on to the top of the open part of the hatch and just swiveling around that part. It looked like he didn't have enough mobility and strength in his arms to actually twist his body down against the force of the suit into the seat.

White After awhile, I reached my left arm underneath, the same technique we had used in the zero-g training, and actually I had my hands all over the circuit breakers.

McDivitt Yes. Ed was a real hazard to the switches.

White Yes, and I pulled myself down in and that's when I really started coming in -- when I got hold of the underneath side of the circuit breaker panel and pulled myself in. That's when my first real progress was made toward actually getting down in.

McDivitt Because, while I could steer Ed from where I was, I really didn't have the strength to pull him in.

McDivitt It was 90° to the way that he really wanted to be pulling. I could steer. I did do a little bit of pushing, but not a heck of a lot. I wasn't really contributing much to the effort there except --.

White You were guiding me down into the footwells.

McDivitt Yes. That was about it.

White But once I got my hands up underneath the instrument panel, I was back pretty well in familiar grounds -- the work that we'd done five dozen times in the zero-g airplane, and I knew the technique pretty well.

McDivitt Ten thousand times! White does check pretty well.

White I really did it a lot. Maybe the suit was stiffer, or maybe I was fatter, but I wasn't going in quite as easy as I had before -- getting into the initial position to pull myself down into the seat. So it took me a little longer. If you recall, I had to go back out again one time. I got back down and started to wedge myself down, and I got two fat cramps at the bottom of my thighs in both legs, where the muscles started to ball up a little.

McDivitt Oh? Did you get it in your thighs or calves?

White Both of the muscles in the back of my thighs balled up in a ball, and I thought, "Well, I have to go back out and let them straighten up." So I straightened my legs out.

McDivitt We had that problem before in the zero-g airplane.

White This is the time Jim said, "Hey while you're up, why don't you throw the visor out?" I hesitated a minute because I thought, "Well, you son-of-a-buck, you might have problems here. You might have to be spending an orbit or so trying to get in."

McDivitt No, as a matter of fact, I don't think that is when you did throw it out. I think you threw it out when you came back down and you started to close the hatch. You were having trouble. It wouldn't close, and you said, "I'm going to have to take this visor off so that I can see these things." And I said, "Listen, if we get this thing closed we're not going to open it again. Throw the visor away."

White That's right. That was when I got the cramps, went back up again, and then I came back down again, and said, "Hey, I can't see them. I'm going to have to take the visor off."

McDivitt No, it was a little bit later than that. You had already started to try to close it, and you were having difficulty closing it.

White Okay. Let's get the sequence out. We came down in. I got up to straighten my legs a little but, went back up, then I came back down --.

McDivitt -- with all your equipment on --.

White I hadn't held the handle yet, had I?

McDivitt No. You hadn't done a thing with it.

White So I got back down into position --.

McDivitt -- with all your equipment on and pulled the hatch down.

White The hatch was down far enough to close at this time.

McDivitt I thought it was.

White I did too. I felt it was down far enough. I can tell by looking right straight down at the edge --.

McDivitt Yes. I can tell by looking up underneath the right-hand side to see where the dogs are.

White Okay. So I thought the hatch was down far enough to close at that time. I reached up and got the handle, but I don't know what I said to you.

McDivitt You didn't say anything. I don't know whether you said anything to me or not, but you didn't have to say anything to me. I saw you move that handle, and I saw how easy it was going, and I saw that the dogs weren't moving.

White I think I said something. I don't remember what I said. But I said something, and you knew right away what had happened.

McDivitt You didn't say a word. I was watching the dogs and that lever, and I knew what the trouble was.

White Right. So I guess that's when I said, "I'm going to have to take the visor off because I can't see." And then we went back up and Jim said "Well, we're not going to open the hatch again. Why don't you throw the visor out." I hesitated for a minute to throw it out because I thought that we might have a problem.

McDivitt Actually, we had a little more difficulty than we had expected. We fooled around for a minute or 2 or maybe even 3 or 4 with the handle. It was pretty apparent to us that we weren't going to get the hatch closed with normal, straight-forward techniques, and that we were going to have to start going to other things. While we say that we came down and moved the handle once or twice, it was over about a 3 or 4 minute period, at least.

White The normal method of closing the hatch is for me to come down and wedge myself down, hold onto the little canvas handle up there, and actually apply a downward force on the hatch to help close it. Then with my right hand I use the hatch handle to ratchet the hatch down. This is normally our technique we would always use, and never in the past has Jim had to help me with the hatch closing device. This wasn't the case this time. As soon as I had gotten up there to operate the gain lever, I couldn't operate the canvas handle anymore. I couldn't apply any torque or pull there because --.

McDivitt Not only that, but you were actually pushing yourself up off the seat. And I'm not sure that even the first time that we had the hatch closed far enough. It looked like it was closed far enough. As a matter of fact, later on when we got it down to that position it looked like it was closed fine. It really wasn't closed far enough because you never did get those dogs out until we --.

White No, the dogs came out, Jim, the first time I got torque on it. Those dogs started out, then it closed.

McDivitt Did they? Okay.

White Yes. I think we had it down far enough.

McDivitt It looked to me like we did, and I couldn't understand why they weren't coming out. I knew that the ratchet wasn't engaged, but I got the impression that it was from watching your hand when you came down one time. You had the ratchet engaged and the little tit pin that sticks in the door that doesn't allow things to come closed wasn't there.

White No, the ratchet wasn't engaged. There was nothing on the handle at all. It was free, completely free. The situation hadn't changed at all. Another thing I'd like to point out now, too, was the chest pack was in the way of bringing the handle down to a full-crank position. And I wanted definitely to do this because you can interrupt the sequence of the dogs if you don't fully stroke the handle each time.

White We went back up so that I could actually see and observe the levers. This was the time Jim said to throw the visor out because we probably wouldn't open the hatch again, once we get it closed. And this seemed like very good sound advice to me. The only thing I was a little questionable about was that at this time I had the inkling in my mind that we might spend quite a bit of time getting this hatch closed, and I might want the visor when I was back out again. But I thought the judgment to throw the visor out was best, and I threw it out -- opened the door about a foot and a half and threw the visor out. The next time we came back down, I was still having the little bit of problem with the cramps, but not nearly the problem I was having with the gain lever.

McDivitt One superseded the other.

White That's right. One problem became of much higher magnitude than the other. So this was the time that we started working.

I knew what I had to do. I knew I had to work the gain lever in sequence with the handle again, just like we had when we opened it. We both had an inkling that this was going to happen when we opened it the first time. But this posed the problem of when I reached up with my left arm to work the gain lever. It takes a great deal of force. This isn't the direction that the suit is designed to reach in. And it takes a great deal of force to lift your arms up in the vicinity of your helmet to operate something there. In so doing it pulled me back up out of the seat. And I think this is the time that Jim noticed that I was up higher than I had ever been before, and he actually felt that my helmet was up against the hatch. I tend to agree that I was up in that position.

McDivitt Yes. I actually pulled Ed down in the seat by pulling on the --.

White I think so.

McDivitt I did it in steps. I'd pull down and Ed would come down. Then I'd pull some more, he'd come down some more.

White I was actually pushing up with my left hand, and my helmet was wedged right up against the hatch. I had a little bit of area in which they actually see the dogs that I was working with up there.

McDivitt You could see them though?

White Yes, I could see them. At least I could see what positions they were in. I could see the little lever operating under the spring -- where I was actually operating the spring on the gain lever. This is where I think we got some very good teamwork, because it was necessary that Jim pull down in conjunction with the time that I pulled down on the closing handle and operated the gain lever. I just hope that the tape worked because I can remember I was in there. Jim was talking to me, and then when it came to the point when we really had to make the big pull I felt a little torque on the handle. I knew that we had it at that time if we could only get the hatch down close enough so that the dogs would engage. And I can remember giving the old -- I think I was yelling HEAVE! HEAVE! Is that what I was yelling?

McDivitt I think so.

White And it was in perfect timing, because I could see Jim or I could see the hatch come down each time that I was yelling HEAVE! I think it was probably the most --.

McDivitt The most interesting moment of the flight.

White Yes. It was the most interesting moment of the flight, but I think it was probably the most, if you want to say, dramatic. I don't know the right word. But it was probably the most dramatic moment of my life — about those 30 seconds we spent right there. The dogs started latching. I could feel them going in, and then I could feel them come over dead-center. Jim called out that the dogs were in.

McDivitt I knew that once we got them moving we'd be all right.

White Yes, once they started coming in. As long as we got those dogs to engage, with the little lever that permitted them to come out and lock, I knew that we had it hacked.

McDivitt Yes. So did I. Even if we would have had to reenter with the hatch in that position, we'd have been all right. I don't think that the heat leaks were that tremendous.

White I knew we could continue and dog it on in all the way. It seems like whenever you know you're right on something, you want to be darn sure that they fix it. This was going through my mind then. And I remember that I felt I was right in that the bar and the attachment on that bar and lanyard were not strong enough. I remembered that, and I knew how hard you were pulling on that thing. I think, if nothing else, they ought to be sure. How many times did we break that attachment at the bar?

McDivitt We broke the attachment about three or four times on the zero-g airplane. Every time they kept telling us it wasn't made out of the right kind of stuff, and the stuff we were going to have in the spacecraft would be the right material. Well, it didn't break in the spacecraft, just coincidently, or maybe because we both had doubts about the strength of that particular piece. The same thing crossed through my mind. I was thinking that the success or failure of this hatch closure depends on whether this hatch closing device stays hooked onto that spacecraft and doesn't break off.

White We would have been flat out of luck!

McDivitt We would have been in deep trouble! I'm not sure we wouldn't have been able to get the hatch closed, because we had put that canvas strap on there and I might have been able to pull you down that way. But I had about all the pull I had in me on that last --

White I know you did.

McDivitt -- on that last thing and I had a lot of mechanical advantage over it. When we went to that canvas strap we would have had to go with no mechanical advantage -- as a matter of fact, a mechanical disadvantage.

White This is one thing that didn't fail, but I recommend that it be made stronger.

McDivitt Stronger anyway!

White I think so.

McDivitt For nothing else than a psychological purpose.

White Right. I'd like to take the spacecraft now and see if I could break it, because I had the feeling that I never had been confident that that attachment nor the bar nor the lanyard were strong enough.

McDivitt When I say I was really pulling as strong as I could, I really had some pull left in me, but I guess what I should have said is that I was pulling about as hard as I dared pull at the time. I guess I could have pulled another few pounds, but I hated to apply more than was needed on there because of the lack of confidence in the strength of it.

White Everything I had was in it over there. I was pulling down with my legs as hard as I could and operating. I was pulling on the handle. I remember one time you said, "Hey don't pull on that handle so hard! You're going to break it!"

McDivitt I was cautioning you to take it easy, which you don't usually have to do.

White This was when we were yelling HEAVE! I was heaving on the handle as I was pulling it down each time. It felt like to me that the handle was giving. But I didn't give a darn! If it broke, it was going to break. So one of the points we learned out of this was we'd like to see the bar and lanyard strengthened.

White Let me say one thing about the decision to go ahead and open the latch. If we hadn't done so much work together with this hatch and run through just about every problem that we could possibly have had, I would have decided to leave the hatch closed and skip with EVA when we first started having trouble with it. We had encountered just every conceivable problem that we could possibly have with the hatch. If it failed we'd know exactly what it was.

McDivitt That's right. I personally had disassembled this cylinder and piston and spring combination up at McDonnell prior to the altitude chamber, so I knew exactly what it was made of. I am sure the problem was that the dry lubrication coagulated, or whatever a dry lube does, and was causing the piston to stick. I knew how we could do this thing. Carl Stone and I had dismantled it and put it back together, cleaned it out, put it back together, relubricated it, put it back together, and it operated fine. I figured out how to make the thing work with it not working properly by using you finger as the spring.

White That's the exact technique we had used.

McDivitt If we hadn't had the training together that we had, and had not encountered all these problems before, I know darn well I would have decided not to open the hatch.

White Maybe we sound overdramatic about the effort we made getting me back in, and I'll honestly say it's one of the biggest efforts I ever made in my life, but I don't think we were all done then.

McDivitt There were a lot of things we could do.

White We could have gone around several orbits working on closing the hatch. That wasn't the last time we were going to get a chance to close it. So there were things left if we understood, and other procedures we could have used to go ahead and close it. When we got it closed back in, I was completely soaked wasn't I?

McDivitt Yes. You were really bushed.

White Sweat was just pouring down. In fact, I could hardly see. It was in my eyes.

McDivitt So I told you, "Just sit there and I'll get a repress. Don't even move for 30 minutes." I just left the repress valve

where it was. I closed the vent valve, and we had a lot of instructions from the ground to close the water seal and a whole bunch of other things that didn't make any sense to me. I knew that the spacecraft was repressurizing. I watched. There wasn't anything else that we had to do right then, and we were both bushed, especially Ed. He was perspiring so that I could hardly see him inside the face plate. So, I just said, "You sit there and I'll sit here and we'll just coast around. When we get the thing repressurized, we'll start doing something." That was exactly what we did. I did finally extend the HF antenna and try to call somebody on HF and let them know that we were back in safely and that thing was repressurizing. I didn't get any response until we got to Carnarvon, which was about 3 minutes later. I called and told them that we were repressurizing and had the hatch closed.

White — You know, that was some pretty good gage reading that we saw when we got the first $\frac{1}{2}$ psi.

McDivitt — The first $\frac{1}{2}$ psi. Ha! Ha!

White — That was really a big one. Since we've described the whole operation, we'd like to go back now and specifically point out the pieces of equipment that we used and our opinions of them, a few features that came out loud and clear to use in operation, general conclusions on EVA as an operation, and what we have to do to make it an operational procedure. So the first thing I'll do is go down through the equipment. As an overall comment on the equipment, I would say I felt very confident the equipment would do the job. And without question the equipment performed as it was advertised. It performed just exactly as it had been designed. There wasn't one thing on them as far as the VCM, the umbilical, the gloves, the gun, and the visor that didn't perform just exactly as it had been designed. I'll take them all one piece at a time, and discuss them a little. I'll start right with the visor. The visor was a rather controversial piece of equipment from the beginning. And I, for one, doubted a little bit the necessity for quite the protection that we were providing, although I had helped right from the beginning in the design with some of our ideas on the visor. It turned out, though and I commented on this during the time that I was out, that I was very happy to have the visor. I was able to look directly into the sunlight. I did so in installing the camera on the back of the adapter. I felt that the vision out of the visor was about as it would be on a normal sunny

day. This is because it is so bright up there in space. I felt as if my vision was what I would consider normal. I was looking at the different parts of the spacecraft and down at the ground, and the view that I received at this time was what I would expect on a normal sunny day. I was certainly glad to have the visor and I left it down throughout EVA. I think on a later flight we might recommend going ahead and lifting the visor and observing any changes we might see in visual acuity when looking down at the ground. The ground vision through the visor really didn't seem to me to be degraded at all. Evidently just the intensity, and not what I was seeing, was cut down.

McDivitt Let me comment a little bit on that visor. I didn't have a visor, and the bright sunlight that was in the cockpit didn't seem to bother me. I imagine that the visor turned out just like a pair of sunglasses. You go outside on a normal day and wear a pair of sunglasses. If you don't have them, you're squinting. But if you start out without them you tend to get accustomed to it. I think I was accustomed to what light there was coming through the spacecraft, admittedly much less than that outside. Ed was accustomed to the sun visor and it turned out just like two people with and without sunglasses. They both could have adapted. I didn't look into the bright sun straight ahead.

White Well, the first time I looked into the bright sun, the first thought I had was, "Boy! Am I glad I've got this visor on!"

McDivitt I know you mentioned it on the radio.

White -- because I was looking right straight into the sun. I had to look into it to attach the camera onto the adapter section. I don't normally wear sunglasses. As you know, Jim, I have never worn sunglasses very much, and I didn't notice it from then on, throughout the time I was out. I had no impulse whatever to lift my visor. My vision was as clear as I could have expected it to be without the visor. There are a few design points in the visor that we could make better and I'll briefly go into them right now. When you are seated in the spacecraft one visor slips up underneath the other and back along the back of your helmet, so that instead of resting on your helmet on the headrest you're resting the visor on the headrest. You certainly don't want to do that. The visor should be restrained in some manner from slipping up along the back of the helmet. Also, my visor was quite difficult for me to raise and lower. Once it was down it fit quite snugly, for which I was happy. But it was difficult for me

to raise and lower. It was actually a two-handed operation, which is one of the reasons why I didn't raise it outside, although I had no impulse to raise it when I was outside. I think that we might be able to design them to be raised up and down more easily.

McDivitt Let me make a comment on that visor. I never did see any need for the little lexion visor.

White That's exactly the point I was going to get to next. I think that one single visor made as close to the helmet liner as possible, providing the maximum amount of headroom and a minimum amount of interference, is what we actually need. I don't believe we need the lexion outer visor. As they pointed out to us, it doesn't really protect, because it bows in and it doesn't really give you the protection that it should be affording. I would recommend one visor, one sun visor only. It'll be simpler to operate.

McDivitt I think so too.

White Okay. The Ventilation Control Module, I can say without qualification, worked exactly as it was planned to work. There was not one complaint that I had with it. It provided me with the proper flow. The flow was less than with the normal ECS suit system, but it was adequate to keep me cool and ventilated, except for two times during the flight. Those times were when I attached the camera right before departing the spacecraft and reentering the spacecraft. But I think it performed without fault.

White The umbilical was another item that I thought performed its part of the flight quite well. I had no complaints about it. I did tend to get it tangled up with the bag and the strings that were attached to the bag during EVA.

White I am very thankful that we decided to design the gloves in the manner in which we did, the two-piece glove that was easily donned or doffed under pressurized conditions. As it turned out, I took them on and off twice while pressurized. I was quite happy that we had them designed in this manner. As it turned out, the heat on the side of the spacecraft, or the cold on the side of the spacecraft when we came out of the dark side, were not noticeable to the touch at all. I didn't use a right-hand thermal glove at any time during the flight. I took it off when I was opening the hatch and, as I pointed out earlier, it floated off during the EVA operation. I didn't have opportunity to use it again if I had

wanted to. Coming back in we had difficulty closing the hatch, and I, at this time, removed my left-hand glove and used the plain pressure suit gloves for this operation. The pressure suit gloves were comfortable. In fact, there were no sensations of either hot or cold through my gloves.

White The gun, I think, was an outstanding point in the flight, a highlight of the flight. It worked just as we had felt it would work and it was, I felt, simple to operate. The training that I had on the air-bearing platform provided me adequate orientation in the use of the space gun. I think that now that we have a little more time to prepare ourselves for the next time we use this gun, training with it on zero-g flights would be appropriate. I don't believe we will have any trouble using it in the zero-g aircraft.

White One mistake that we made on our EVA equipment was the mounting of the Contarex camera. This camera should have been attached by velcro to me, so that I could use it independently of the gun. It would have been easier for me to use, and I would have had a much higher probability of getting satisfactory pictures with it. It was a case of lumping too much together -- putting the gun and camera together.

White The attachment of the VCM to the harness was a good type of attachment. It was easy to disconnect the two velcro attachments and move the chest pack in and out. I had to do this both when I opened the spacecraft hatch, so it would clear the hatch handle, and I had to move it out of the way when I closed the spacecraft and pumped the hatch handle.

White Now we can get into some conclusions. While I was out, I decided to put a piece of velcro strip on the side of the adapter to see if later on we might use this as a method for attaching items on the outside of the spacecraft, if the velcro was still there and if it was in good shape. I think the velcro could be made into a very useful item for a type of tether. I think you might even be able to do something along the line of just having some female velcro on the gloves and pieces of the male velcro at points along the adapter. This might provide us at least some attachments so that we could maneuver ourselves back to the adapter section. This would be about the simplest kind of handle that we could use. I do believe that we need some type of handles on the outside of the spacecraft. Jim suggested one on the nose and in the cover on the R and R section up there. I think this is an area that we certainly have a possibility of using. I

certainly would have found it useful. I would still be a little hesitant, though, of breaking the antenna. You would want to be sure that this wouldn't be broken during EVA. I think the feeling I had out there, again, was like holding onto an 8-foot tree. There wasn't anything to hold onto. You definitely need some kind of hand-holds. The decision to leave the hatch open was one of the best decisions that we made. It provided me with a center of operations for my work. I was able to stabilize myself by holding onto the hatch. It was also surprising to me how much force it took to open the hatch the first time against the preload and the actuators, due to the seals. One other very good decision was to have me wear the heavy suit and Jim the light suit. I think this was one of the things that made our operation easier. It certainly made my getting back in the spacecraft and Jim's assistance in closing the hatch much easier for him. Also, I was handing him things in and out. He was performing quite a bit of coordination in the operation with pieces of equipment that were going in and out of the spacecraft, and I believe that by being in that light suit he was able to do this much easier than if he had been in a heavy suit.

McDivitt I might make a comment on that suit, too. When we opened up the hatch we were in a vacuum. I noticed that the temperature of the suit dropped slightly so that the suit was a little bit cooler inside. I was wondering if I was going to get too cold through the suit, but the rest of the time we were out the temperature never changed. I don't remember looking at the suit inlet temperature, but the suit itself stayed reasonably warm. I had sun in the cockpit, and I had the cockpit open without the sun in it for a relatively long period of time, 4 or 5 minutes at a time. This didn't seem to affect my temperature inside the suit.

White I think you felt the temperature more than I did.

McDivitt I felt the temperature go down, rather than up.

White I felt that also while outside. I would say it was a very comfortable figure. I figure that I was probably at 68° temperature out there inside the suit, which was cooler than I had been anytime during the flight. It wasn't a cold feeling, just a very natural comfortable temperature.

McDivitt Suit inlet temperature was running about 55° during most of the flight. It got down around 52°, so it probably might have even been cooler than your 68°.

White Well, it was cooler inside the suit when I was outside the spacecraft than at any other time during the flight. It wasn't uncomfortably cool there at all.

White I think that we can go on with some conclusions. Some conclusions that I had were:

1. I didn't notice any extremely hot temperatures on the outside of the spacecraft. I also didn't contact surfaces for any period of time to transfer much in the way of a heat load to any part of my suit including the gloves.

2. There's a definite requirement for some type of hand holds outside the spacecraft.

3. We should think a little more on where we want to operate during EVA and where to attach the tether. The tether was not attached at a point that would provide me the capability to operate in the area that I wanted to.

McDivitt You couldn't get to the nose. It provided great operation for directly above.

White Straight above.

McDivitt I just don't know how you would get the thing out there. You would have to run it along the spacecraft, then attach it somewhere at the front.

White It would preclude operations in other areas. You would either have to accept where we are going to operate or --.

McDivitt You could have multiple attachment points around the spacecraft.

White Of course, now, if you have a gun with a good air source, I wouldn't particularly care where it was attached. I think you could go ahead and, maneuver to any point you want if you have a gun. Again, where you're pushing off of surfaces, you tend to go perpendicular to the surface from which you push off. I found when I pushed as hard as I wanted to I'd still tend to go straight up above that hatch instead of out toward the front. I think this is a fairly obvious conclusion, but it proved out. Every time I pushed off I went straight up instead of at an angle to the surface where I wanted to go.

McDivitt Something that you should bear in mind is that you were pushing off from the front, which tended to make the front go down as you went out.

White Yes. Everything was working against getting where I wanted to go. Everything I did tended to put me up.

McDivitt When you started you went in a straight line forward and tended to push the spacecraft down. I think, initially, where I was holding the attitude, you didn't have that much trouble. Of course, you weren't pushing as hard either, because you had the gun.

White No, I wasn't.

McDivitt Later on, when we started free drifting, you were back behind me where I couldn't see.

White Did you feel me stomping around back on the adapter and hitting the adapter?

McDivitt Well, I felt you hitting things back behind me, and once you went behind the line that was directly overhead the spacecraft. I couldn't see you through your open hatch.

White I never really had a good contact with the adapter back there.

McDivitt Just as well. We wouldn't want to disturb those radiator tubes too much.

White No. Well, now that we're back, we'll have some conclusions on the adapter area. I made it a point right from the beginning to take a look at the thermal lines, the thermal paint on the adapter. It looked like it was in good shape. It was all there. There was discoloration around the attitude thrusters, particularly from the thrusting. The color of the thrusting is just like the RCS thrusting -- nice and clear plume. It looked like from outside, though, that I could see a lot more of the plume than I could when I was sitting inside the spacecraft looking out at the RCS thrusters firing. Again, the camera was not attached in an opportune manner to operate.

McDivitt Which camera? The camera on the spacecraft?

White I'm really after that camera on the gun. That one wasn't attached good. The camera on the spacecraft was okay. It was a little difficult to attach because of the attachment

on the bottom of it. You can't have it at any angle to make it engage. It has to be perfectly flat with the mounting plate on the bottom. A big conclusion that I came to -- and I'll see how you feel about this one, Jim -- I feel that storage in the back of the adapter section was certainly a very high priority for later missions. I feel that we can adequately store equipment in the adapter area, particularly larger pieces of equipment that we don't have room for in the crew station or pieces we don't have particular use for in the early part of the flight. If we can lick the problems in opening and closing of the hatch, we can store equipment in the back of the adapter section as a routine operation.

McDivitt That's right. I think the extravehicular activities have proved to other people what we already knew a long time ago -- that EVA is quite simple. I think the thing we've got to iron out is the hatch opening and closing. This is really our problem. I don't think you or I will ever have any doubt about the extravehicular activity. That was, I thought, going to be pretty straightforward. It looked like to me it was pretty straightforward.

White I felt that I could operate equipment out there. I could assemble equipment. I could put pins in, pull pins out, and screw things in. I did all these things during the flight. I turned the gun on, and I put in the pin to operate the umbilical guide. I attached the camera. I don't think you could do these operations very effectively with big heavy gloves on. Although my gloves operated satisfactorily, I think that for assembly of items you want to have -- you ought to look into the glove area a little more thoroughly and try to get a piece of a glove with some type of a surface that will give us some heat protection and gives us a high sensitivity of feel through it. The big conclusions, the final conclusions, that I'd like to draw are that EVA can be made a normal routine operation if the following modifications are made to the spacecraft:

1. The highest priority is that the spring back there on the gain lug has convicted itself, and I don't believe that that's a good design. There should be some way that either the lubrication is made foolproof or the spring made stronger.

McDivitt I think that we really want to say here is that the locking mechanism is inadequate as it is, completely inadequate. Until it is fixed, I think we should take it easy.

White That's right. I think we almost had a bad experience with that gain thing. We knew about it ahead of time. We thought we had it fixed, but it's not fixed. I think it convicted itself, and it's guilty, and it has to be fixed.

2. I recommend that at least the egress kit on the right of the crew compartment be removed to provide more room in the spacecraft. I see no reason for it being in there. I think it would be worth the effort and the additional money to provide the extra room in the spacecraft. So, my second recommendation on EVA is to remove the egress kit, at least from the right-hand side, to provide more head room.

McDivitt Yes, that's good. I might add that it's a good thing that we had that egress kit modified to the minimum height, because without that we would have been in deep trouble.

White That's right.

White Yes. You and I had been telling each other that that was the biggest thing we did on our whole 9 months prior to the flight — to get that thing cut down. I think it sure paid for itself on our flight.

3. My third item is to make the bar and lanyard completely foolproof in strength. That was a device that provided us with the added force we needed to close the hatch, just as we sat there and said we might need during the SAR of the spacecraft in St. Louis. I think the attachments of the bar and the cable to the spacecraft should probably be at least doubled in strength, so there just isn't any question in the pilots' minds or the engineers' minds. I guess the engineers were convinced that you didn't have Jim and me convinced that those two attachment points --.

McDivitt We've seen it break too many times, I think.

White We've broken the bar, and we've broken that attachment point. I had actually physically twisted the attachment right off the spacecraft up in the zero-g airplane. I certainly wouldn't have put my full strength into it if I knew my life depended on that attachment. It should be made absolutely foolproof.

McDivitt Well, that was the point I was trying to make earlier when I said I was pulling as hard as I could. Then I said that I really wasn't pulling as hard as I was capable of.

White You didn't have confidence in that attachment.

McDivitt I didn't really think that I should pull on it any harder.

White No. I think that should be the third recommendation and it should be corrected.

McDivitt I think we could spare a couple of extra pounds of weight there, just for the pilots' peace of mind.

White That's right. Take the time it takes to put a new attachment on there. They told us they didn't want to do it because they'd have to rerig it. I think they'd better rerig it and take the time to put a good attachment on there.

4. The final thing really doesn't fit in with the first three recommendations, but I would sure like to have the opportunity to use that gun again with about a 10-times supply of oxygen in a great big canister. I think that maybe this is one of the items we could carry in the back of the adapter. We could use a small supply to provide the means to go back there to get a great big canister. Then we'd have a unit that we could actually do some maneuvering with.

McDivitt That's right. I think that, in essence, we proved the usefulness of a self-stabilized or a man-stabilized maneuvering unit --.

White Yes.

McDivitt -- rather than one that is gyro-stabilized with automatic stability features. I think that although you didn't burn up a lot of fuel, you certainly proved the feasibility of this type of maneuvering unit.

White We had an awfully small amount. We just had the 6 feet/second.

White We proved, in my mind, that I had the capability to go from Point A to Point B with that maneuvering unit.

McDivitt Let me ask you this question, and be honest about it. Would you detach your tether and go without it? Don't be too optimistic, because other people's lives may depend on it.

White I think that we probably have not done enough investigation to do that at this time, but I feel we are progressing toward the point. We made the first, say 50 percent, of the step toward being able to detach the tether and go. I don't believe that I would detach the tether and go with that 6 feet/second --.

McDivitt Oh, no. I didn't mean that. I mean with that type of unit.

White If I had some more ΔV in a unit like that I think that I would be willing to detach myself on the next flight, right now, from the spacecraft and go. That's combined with two things, you see. You have two things working for you. You have the capability to maneuver yourself, and, if you should get out of control, the spacecraft still has the capability to come over and get close enough so that you could get yourself back in control and get in the spacecraft.

White I think that 40 or 50 feet/second would be a minimum. I had 6 and I'd like to see, probably, a capability of about 10 times that. That may be a little --.

McDivitt It's difficult. I would think it would be difficult to fix a number on it until you fixed the job.

White Yes.

McDivitt If you wanted to go to something that was 10 feet away and come back, you'd probably get by with 20 feet/second.

White If I wanted to get out of the spacecraft and go along to the back of the adapter and get in the adapter without being attached to the spacecraft, I'd only need two or three times the amount. I'd be happy to go with that.

McDivitt There are some problems in the capability to aline one's self onto an object. I think chasing the booster around points this out. You say you'd be willing to go away because the spacecraft can come and get you. Admittedly it can, but keep in mind the difficulty we had with the booster. I don't really anticipate us ever getting into the situation like that because you'd never get so far away that you're in different orbits, like we were with the booster --.

White What I visualize is a 25 to 50 foot operation where you're going out to investigate either another spacecraft or another satellite up there, or making a transfer similar to the type of transfer that we visualize as a backup mode for Apollo. I think with the gun I had, if the LEM and the Command Module were there, I'd be satisfied to depart the Command Module and maneuver over to the LEM situated 10 to 20 feet away from the Command Module. I feel I could do that at the present time. I don't think it would be a very smart thing at the present time to go maneuvering off 200 to 300 feet away from the spacecraft with this type of device. I think this device

is designed and has its greatest usefulness in close operation around the spacecraft.

McDivitt That's right. There is no need to maneuver off about 400 or 500 feet away, because if you want to go that far, use the spacecraft. This gun is for a close-working job.

White I think it's a valuable tool in this manner.

McDivitt Okay. That's the same conclusion I came to. We'd be willing to do it at close range.

White I'd be willing to do it right now. I might not go tell somebody else to go do it, but I'd be willing, with the training that I had with it, to transfer 15 or 20 feet without a tether. But I think we should spend some more time with the gun.

McDivitt I think so too.

White I also think it would be of value to go in the zero-g airplane with it.

McDivitt Yes, I think so too.

White I think the work that we might do in the zero-g airplane doesn't necessarily have to be done in full regalia, with all the pressure suits in a pressurized condition. I think we can go up there and learn a lot about the gun without pressure suits on, in a plain flying suit type operation -- perhaps polish the training off with a little work in pressurized suits. If you work in the zero-g airplane with a pressurized suit, it's pretty awkward.

White In pitch and yaw I felt I could maintain effectively zero rates. I don't know how it looked to you, Jim, but it looked like I could establish a rate and take the rate out without too much trouble. The yaw is the lowest moment of them all. Pitch was very easy, just to pitch the thing up and down. I'm still a little suspicious of roll. That's the area that I would like to look into a little more. I think that you could get yourself into a kind of balled up situation with pitch, roll, and yaw all coupled up. It might take a little bit of fuel to get yourself straightened back out again. But just in translating from Point A to Point B, you could care less if you rolled, as long as you kept pitch and yaw straight. And that's why I say I think you can translate and correct pitch and yaw very successfully and effectively forget about roll, just as we do in our reentries or our retros.

White The question is: Was there any problem with the gun of maintaining a fairly well stabilized attitude and still get my translation input? I did this actually three different times, and this was what I had done when I was coming back to the spacecraft the last time. I had to put in both pitch and yaw and had taken them out and I was coming back. I was going to fire my last thrust toward the spacecraft. I got a little burst. I could feel a little burst and then it petered out. But you can put a translation in. I was also surprised that I was able to stop at the time I tried to stop it out there, about one-half or two-thirds of the way out on the end of the lanyard. It seemed to stop pretty well. It was either the gun or the lanyard dampening me. It didn't dampen me in roll, so I think it was the gun that actually did it.

McDivitt I think that this previous bunch of words just spoken covers a lot of detail of the first three or four orbits of our flight, and it covers that first phase of mission sequences that I first mentioned. I think the next thing we should do is go through the interim orbits, about 50 or 55, or however many there were, where we set about to save up enough fuel to do something constructive, to check on our orbit to see what it was, to see how we were decaying, what our lifetime expectancy would be, and perform the experiments that we'd initially set out to do on our flight plan. Although it's not going to be of much use to go through it in a chronological order, I suppose that is probably the best way. As I just finished saying, we're not going to get an awful lot out of going through the flight plan sequentially, but we'll do it quickly, and then we'll come back and discuss each experiment or operation, check an entity in itself, and we'll discuss the systems as an entity, too. We'll do this, generally, in elapsed time.

McDivitt Going back to the EVA for just one moment. I'd like to say that the use of the manual heaters on ECS O_2 bottle was about two 5-minute periods separated by about 10 minutes. We really didn't need an awful lot of manual heater when we were doing the extravehicular activity.

4.3 Other Orbital Operations

McDivitt Let's see. One thing that we did was to turn off the ES Sensor at 6:35. You have notes along there?

White I got all the sensor stuff down, I think, pretty well.

McDivitt Okay. I have the ES sensor and the Bio-Med recorder no. 1 going off at 6:35.

McDivitt At about 7 hours elapsed time, I checked the OAMS fuel remaining. We had about 62 percent indicated, 2100 psi, and 88° temperature. We kept getting our GO and NO-GO checks as per flight plan. At about 7:30 Ed went to sleep.

McDivitt We didn't do any lifetime adjust maneuvers. I turned the spectrometer-magnetometer on. This was while Ed was asleep. Extended the boom, got the ES sensor on, and left the spectrometer-magnetometer on for three passes through the South Atlantic Anamoly. I couldn't really see any increase in the ammeter when we extended the thing. We went through a number of extension cycles throughout the flight to make sure that we got the thing out. At no time during the flight did we ever see a rise in the ammeter when we extended it. The way it operates is, it has three positions: EXTEND, OFF, and RETRACT. It was in the OFF position and I put it to the EXTEND position. Then I put it back to the OFF position. Periodically throughout the flight we put it to the EXTEND position and back to OFF to make sure that if it got screwed up the first time that it would go on out. The first extension was supposed to be with the spectrometer-magnetometer on. So, I checked to see the circuit breakers were on, and they were on. I turned the spectrometer-magnetometer on, and then I extended the boom. And in this way the experimeters hope to get some indication from the lines of force that they were picking up if the thing actually extended at that time. I hope they got it.

White Incidentally, you got a pretty good operation on the swizzle stick. I was asleep and Jim was doing that on my side.

McDivitt That's right. I did it with the swizzle stick way over on Ed's side. I didn't aline the platform or anything. We were in free drifting flight at this time. As soon as we finished the EVA, we went into free drifting flight. We powered down the platform and the computer, shut off the attitude indicator lights--we went through a complete power-down procedure. We were really trying to save battery power, OAMS fuel, and everything else we had. We went on a complete power-down, down the checklist, and we just didn't have anything on.

McDivitt And we stayed in this free drifting mode for about 2 days. That right, Ed?

White Closer to $2\frac{1}{2}$ days.

McDivitt Mostly for the first $2\frac{1}{2}$ days we were in a free drifting mode. We didn't do the platform alinement and the translation at around 8:10--8:20 in the flight plan. We did not obtain any booster-star measurements. As a matter of fact, I'd like to comment on the booster-star sightings, or just the booster sightings. We saw the lights of the booster definitely on the first pass as we were tracking it. The second pass, as Ed said, he saw them, and he said he was sure he saw them because they were flashing. I was pretty sure I saw what he was talking about. However, this occurred just at sundown. Every other time at sundown we'd call out the booster a couple of more times before we finally figured out that this was not the booster, but a planet.

White One or two times I'm fairly confident I saw the booster.

McDivitt You're pretty sure you saw it?

White Yes. That was the booster.

McDivitt Well, I was pretty confident that I saw it flashing, too. But later on I watched that star, that particular planet, come up. I sat right there and watched it, and it flickered as it came up through the atmosphere.

White Yes, I agree with you.

McDivitt So it could have been that we were just really looking for the booster, and at that particular time we looked out and saw this thing and it flickered. I spent one whole sunset doing nothing but keeping my eye out for that planet. Sure enough it popped up and I saw it.

White But, you know, never flickered.

McDivitt It flickered. I watched it as it flickered. It flickered all the way up. I watched the thing as it set, and it flickered all the way down--the last at 10° or so. This is exactly where we thought we were seeing the booster, right where it was low on the horizon, as you would expect to see a booster. That old thing was flickering away like mad.

White I think that was Venus, too.

McDivitt It was the planet that was trailing the sun by just a very slight amount. I made it a point to check during the remainder of the flight, two or three times, to see if that thing flickered as it came up. It really did. So the more I saw it flicker, the more I began to doubt that we had really seen the booster on that second pass. Maybe we did, and maybe we didn't.

White Well, it's not really too important.

McDivitt No, it's not. But the fact is, that little planet was flickering away like mad.

White Let me ask you one more question about the flicker. Did you see it coming up through the airglow? Was that where you felt it flickered?

McDivitt Yes.

White Everytime it was above the airglow it was loud and clear to me.

McDivitt Yes, except that you couldn't see the airglow as the sun was setting.

White That's right.

McDivitt Initially you saw the sun out there, and you saw this thing looking like it was flashing. Once it got above the airglow, the planet did not flicker anymore. It was perfectly bright.

White Very bright.

McDivitt When we saw that thing that looked like the booster, it was very low on the horizon. It always popped out. Remember how that bright light used to pop out? You'd have the light sky, and all of a sudden there'd be a bright light there.

White We saw that planet come up so many times during the flight, I feel quite convinced that the first sighting or two weren't of the planet.

McDivitt Well, maybe it wasn't.

White Actually, I continued to see the blinking on it after the stars were out.

McDivitt Wait, let's take a look and see which way the booster would be. The booster was below us so it should be going out in front of us like mad. You're looking into the sunset which was behind us. The booster shouldn't have been there. The booster should have been out to the front of us. It should have been in the opposite direction.

White I'm not convinced which way we were looking.

McDivitt We had to be looking to the rear. The sun sets to the rear. We had to be BEF to see the sun when it set. You see, you're BEF to watch it set.

White Were we BEF for the full time, or were we in free drift?

McDivitt We were in free drift, but this was near the sun when this thing came out.

White No, they always come out loud and clear when you're away from the sun, when you're looking away from the sun.

McDivitt Yes. I know it, but at that one time when you said, "There's the booster," you were looking at the sun. Remember, I had turned around? They told us that they wanted us to be BEF and heads down when we opened up the hatch. That's where we were. I turned around to be BEF. We were BEF when we saw that thing.

White We'd better look at the tapes. I think we can probably get better information on this when we check.

McDivitt I think we were even looking in the wrong direction. The next pass around I called out and said, "I see the booster on top at 9 o'clock, perpendicular to our flight path." I don't think that was the booster either.

White It's kind of academic.

McDivitt Yes.

White The reason that I brought the thing back up again is I wanted to be sure it's brought out that the planets are so clear and so bright, even far brighter than they are looking at them from the ground. Looking at them up there, it really is striking the first time you see them. If we took a lot of pictures of anything, it was a picture of that planet.

McDivitt Sunrise and sunset. The sunsets all had the planet in it.

White That's right. That planet has always been there.

McDivitt Very pretty.

White It certainly was.

McDivitt Okay, I got a call after Ed went to sleep that we were going to pass by Typhoon Babe which would be north of track, at 7:56.

White I wasn't sleeping. I heard it.

McDivitt Did you? Okay. Well, I didn't have any fuel to point the spacecraft at Typhoon Babe so that was that. If I had drifted around so I could see it, I was going to take a picture of it, but I never drifted around so I could see it. I just passed on by. A little bit later on, I was called up and told that at 23:55 G.m.t. my ascending node would be at 83° East on my 6th rev. This was just a map update. I was told I should eat at some particular time. I think it was 00:15 to 01:00. It was already past that time, so I ate when I felt like it. The pilot was supposed to do a no. 1 Aero-Med pass at 02:17:43. This was the first instance of us running into a case where a man was supposed to do an Aero-Med pass when he was asleep. This continued intermittently throughout the flight.

White It seems like I was always asleep when I was supposed to be doing an Aero-Med pass.

McDivitt This continued on intermittently during the flight. As the flight progressed, the doctors got more coordinated on the ground, and we got more coordinated with them to tell them who was sleeping and how long we were going to be sleeping. We had less requests for Aero-Med passes of guys that were sleeping. We, in general, refused to wake the other person up to do an Aero-Med pass. We were told by the doctors and the flight planners on the ground that at 02:30:59 we were supposed to turn on D-8. Now, I don't know why we had to have this to the nearest second. I was also supposed to go to sleep at this time, to the nearest second. It seemed a little academic to me. So I woke Ed up at 02:30 Greenwich time. He turned on the D-8 Experiment and I didn't go to sleep until I did something else. I think I had something to eat but I'm not real sure. But I didn't get off to sleep

right away. Then I told Ed he was supposed to turn that MSC 2 and 3 off at 03:00. I awoke at 06:15. But what happened in between that elapsed time, Ed? Shoot, that's not right --

White 06:15?

McDivitt I must have awaken --

White About 4 hours is what you had.

McDivitt Right. Looking through my notes here I see that I wrote down "Awake at 06:15," and I didn't get to sleep at 2:30 and Ed didn't wake me up at 6:15. So I guess we were down from anywhere from 3:30 and 4:30.

White Right. You slept approximately 4 hours. I let you go about 30 or 45 minutes after that time of 6:15, as far as getting you up. While you were asleep, the things that I did: I believe that I had a meal which you had gotten out. I believe we had one before this, though. Didn't we have one after EVA before I went to sleep? Or did I just drink a lot of water and go to sleep?

McDivitt No, I think we had a meal before you went to sleep.

White That was my second meal that I had shortly after I got up. I believe they called and asked me to give them an aero-med pass, which I don't have the time logged on. I imagine the medics will have that. I ran through a D-8 Experiment at 02:30:59. The MSC-2 and-3 recorders were supposed to come off at 3 o'clock, but I didn't turn them off til 04:19:40. It didn't seem like that was particularly important anyhow to get them off. I guess that's why I didn't think about it. I got instructions from the ground to maintain the oxygen pressure at between 930 and 960, with the O_2 high rate. This is the time I told them that the command pilot was asleep, and I'd prefer to do it at a later time. I think they called me back a few times on it; finally, when it got up to about 960 I went ahead and dumped it.

McDivitt It scared me to death!

White The O_2 high rate started filling the cabin up, pressurizing it up around 5.4. At 5.4 on the button the vent valve relieved, and Jim about came through the top of the hatch.

McDivitt I was there half asleep with my gloves off, my visor down, and a cover over. The cabin vented and the cabin pressure dropped about 3/10 of a pound. I knew that I didn't have my gloves on and I figured, "Boy, I am going to have to get those gloves on in the next half a second or I'm going to be --"

White He didn't get his gloves on, but he sure was thrashing around for a little while till I got him the word. I didn't want to wake him up. I was hoping it would go through without waking him, but it sure didn't.

McDivitt Man! It liked to have scared me so bad I don't think I went back to sleep.

White No, you went back. You slept better at the end of your sleep cycle than at the beginning.

McDivitt So you were trying to get to my end earlier..

White I think I did the other. I always slept best at the beginning of my sleep.

McDivitt No, I always slept best at the beginning.

White You did too?

McDivitt There was a period where I had to get to sleep, then there was a period of solid sleep, sometimes 15 minutes, sometimes an hour. But after I went by that first bunch, then I was in a state of semi-wakefulness.

White Kind of like dopey, fitful sleep. That's the same type of sleep I had, at least until the last time. Okay. There really wasn't anything else that went on except a few tape dumps and an update for the orbital plotboard. I found this to be very useful. I used the plotboard to keep track of my orbits, where I was during the first part of the mission, exclusively. It was very accurate. You could check the times in the plotboard as against what you saw on the ground and you could locate yourself quite adequately. How about you?

McDivitt While I'm think about it, I though the plotboard information early in the flight was excellent. But I thought that the plotboard information at the end of the flight was not correct. As a matter of fact, I started to call them a couple of times, but I never did. By the time I would get the stuff plotted, and get the map put where I wanted it, we would be someplace

else. I'm sure that that information they were sending up to me wasn't right; I'd be off an orbit or two.

White After about the last day and a half, I used the nominal orbit plot maps exclusively. I could see the time and the location. I could spot it right with the ground. And I think I figured it was 7 minutes behind near the latter part of the mission. This didn't bother me. I could tell how far it was behind, and then update my position on the map quite easily. I thought those preplots were real good.

McDivitt So did I. I thought they were, too. But I was a little disappointed with the map information at the end of the flight. I don't know exactly what was happening. But I'm convinced that it wasn't right. As a matter of fact, a couple of times I was even on the wrong orbit. They'd give me a time and a longitude and I'd plot it. I wasn't even over that part of the world. I'd be over a whole orbit from that.

White Jim, I made this mistake once, too. I was using my plot-board. I'd plot everything out and I came down in a place in Mexico at night, Tampico, Mexico. So I told them something about seeing this spot in Mexico. They didn't pick up my mistake. I was back checking over and I got to looking at my map and said, "What the heck are we doing here at night?" I was actually on the other side. I was clear around in Australia.

McDivitt Had you plotted east instead of west?

White No, I don't think I did. I think I plotted it correctly. I went back and checked it and I never did get the plot. I went on to do something else, and I didn't get the plot-board squared away on that. But I realized that instead of passing over Tampico, Mexico, what I was really seeing on the ground was Sidney.

McDivitt You only missed it by half the world.

White That's right. It was exactly on the other side. But not exactly. It was about 120° off.

McDivitt Mine was something like this. One that I remember specifically--they gave me a map update and they wanted me to do a check over El Paso and El Centro. Looking at this I could see that if I was at the right time, I would have come up from the south; whereas, my pass was down like this, and I was an orbit or two off.

White Well then, we're not talking about the same thing. I think I had probably slipped it somehow on here.

McDivitt You might have plotted 60 East instead of 60 West, or something like that.

White Yes.

McDivitt But I was off by a time factor.

White It wasn't too hard to realize that Mexico wasn't at night.

McDivitt I have a note here that says, "RKV tape dump and a no. 1 medical pass on the command pilot at 07:02 G.m.t."

White That's right. And I got you up a few minutes before 07:00, if you recall. In fact, just before you had to make your medical pass I woke you up. So I'd estimate that Jim got up around 6:55, just enough time to transfer the equipment to him and let him make his medical pass.

McDivitt At 7:15 Greenwich time I was supposed to eat.

White Right. At 11:15 Greenwich time I was supposed to go back to sleep.

McDivitt Is that when you did? I don't even see that on here.

White Where it says "Pilot sleep."

McDivitt Is that a penciled-in note?

White There was just a series of instructions that we got from them.

McDivitt Okay. Good, because I don't have that.

White It doesn't really mean that's when we went to sleep, because you know we did things somewhat out of sequence.

McDivitt At 8:55 over the RKV we got a list of PLA's and CLA's.

White Was this one of our first big batches of them? You know, initially, we didn't get too many of them, and then we started getting them on a very regular basis throughout the flight. I thought that communications of those was quite good, once we started.

McDivitt I have a list of notes here that say: Rev 12 was over the RKV where we were supposed to get the CLA's and PLA's. We did. Rev 13 was over Canary where we were supposed to have a C-band track. I think that meant C-band went to CONTINUOUS, but I'm not really sure.

White This is the time at about 17 or 18 hours that I called down and asked them how the tape dumps were coming out, because we weren't holding any attitude for them. We were holding nothing more than a drifting attitude, and I know that over some stations we were blunt-end-down and rolled upside down. We were talking, I know, upside down to the stations and getting good transmissions through. They came back and said all of the tape dumps to this time had been excellent.

McDivitt At a G.m.t. of 12:16:00 I got a comment: "No fuel, but do a flight track orientation." This is like saying, "Drive from here to the drug store, but don't use any gasoline--and don't take the car."

So as I flopped over near around 12:16, I looked down to the ground. We could do a flight track orientation pretty well, considering that we had this movable orbital map, and we had a pretty good idea of where we were going to be to start with so we could pick out where we were. Got a map update at 10:17:49, 73° West. A tape dump at Canaries on Rev 13 and at Carnarvon at Rev 14. Around 19 hours, I checked on our orbit and it was 155.7 by 88.

At 11:52:43, turned the C-band adapter switch to CONTINUOUS. At 11:59:23 we turned it back to COMMAND. This is Greenwich time. All the stuff in the flight plan such as the orbit navigational checks and the Apollo landmark investigation were not done. We were doing tape dumps, medical data passes, and that was about it. The next M-3 Experiments were all part of medical data passes. I don't even know why they're in the flight plan.

White I couldn't figure that out either.

McDivitt We did an HF check. Check began at 16:58:30 G.m.t., and ran on through 19:07:00 G.m.t.; this included the sunrise, sunset, day and night--all the HF checks, and will cover those in the experiment part of our debriefing. During this period of 16:58:30 G.m.t. to 19:07:00 G.m.t., we did the HF checks.

White Oh, here it is? Command pilot asleep.

McDivitt Where?

White At 11:45 Zulu. Pilot awake at 11:30. I don't know when I went to sleep here.

McDivitt Okay. Let's check that some other time.

White Okay.

McDivitt It'll take a long time to sort that out, and I don't think he needs that right away.

White All right. I got command pilot asleep at 11:45.

McDivitt Okay. I don't have me up or asleep or anything. What I've got here in my notes is: Ed to bed at 20:15, up at 22:15, back at 23:15. These are Zebra times, I'm sure. So I don't know exactly what happened in there.

White Well, you're clear over on 24 now. Okay, you've skipped the time when you were asleep.

McDivitt That's right. I don't have anything on that.

White Okay, I have you going to sleep. I logged myself awake at 11:30. Command pilot asleep at 11:45. These are Greenwich times. If you add 8:45 onto that, it comes out 20 hours and 30 minutes, elapsed time. You gave me the instructions for the C-band adapter times. I did turn those on at 11:52:43 to CONTINUOUS C-band on the adapter, and at 11:59:23 to COMMAND. Also during that period of time, I had been told to go ahead and run Apollo landmark investigation without any fuel. But luckily, the spacecraft rotated right around as we came up to it, and I was looking right down at the junction of, I believe, the ... and the White Nile.

McDivitt That's right. That was the first task we had of finding something on the ground.

White Yes, it really worked.

McDivitt It was no trouble.

White It really worked. That was the one that I was probably most familiar with. It's such an obvious one. It's out in the middle of the desert and it's the intersection of the big Nile, where it junctions into two other sections, a little island and a northern tip of the island. I was able

to pick the island up from the tip quite clearly. I did take a couple pictures, I believe, of it, but we were just passing and I wasn't tracking. I did report that it was a good landmark and quite easy to see.

We did get an instruction at this time to go to the normal flight plan at 22 hours. This was something that was kind of hard to do. I don't think we really ever got back on much of a normal flight plan for the whole flight, but we did get instructions at 22 hours elapsed time to return to our normal flight plan. At this time Jim was still asleep. We got the update that the Hawks won 3 to 2.

McDivitt Ha ha ha ha ha!

White I relayed that information to Jim when he woke up.

McDivitt That's right. Okay, I think we've already covered our HF checks, which were part of the regular flight plan.

White Yes, we did that.

McDivitt I said they were between 16:58:30 G.m.t. and 19:07:00 G.m.t.

White Right.

McDivitt We scrubbed the Apollo landmark investigation at 28:40 and again at 29:10. We were allowed to do the D-9 at about 29:30 in drifting flight only. Doing the D-9 in drifting flight means that you look outside with the sextant and you pick out whatever two stars are there and you measure an angle between them. It was a qualitative rather than a quantitative type investigation for the experiment. I'm telling you, with D-9 it was mostly qualitative throughout the whole mission. We did a few quantitative things, but the number of quantitative things that we could do were very limited.

White The HF test took us one and a half orbits.

McDivitt Yes. It took 2 hours and 15 minutes at least.

White I think around 28:30, we had a call up for D-9.

McDivitt Yes. This is where we did D-9 in drifting flight only.

White Yes, and again that was like taking the car out of the garage without gasoline.

McDivitt All it amounted to was looking through the window and picking out two stars that you can see and taking a sighting between them. Just a qualitative check to see what the sextant would do. We did that. D-9 turned out to be a qualitative, rather than a quantitative experiment, except in a very isolated instance. We weren't even stabilized.

White You were trying to talk me through some of the things, but I had the helmet off and on--

McDivitt This was when we first discovered that the light bulb in the readout portion of the sextant was burned out or something was wrong.

White Right.

McDivitt We couldn't read out the angle.

White We called down, but we never got a call up on that or any instructions.

McDivitt Well, there weren't any. Ha ha ha! Okay, then I have in my notes here, as I mentioned earlier: "Ed went to bed at 20:15, got up at 22:15, and went back to bed at 23:15." That's all Zulu time, but I don't see when he finally got up for the last time.

White Maybe I've got it in here.

McDivitt We had another map update in there but it's really not important. We scratched the Apollo Landmark Investigation--

White What time did you have me asleep? 23:15, Jim? Okay, well I obviously was up shortly thereafter because I got on the horn, and you were asleep when they called us up and told us we'd passed the U.S. space record--

McDivitt That's right.

White At a little past 32 hours, which is 23:15. That's 32 hours. The space record was 32 hours.

McDivitt We cancelled the Apollo Landmark Investigation, Run 3, at 30 hours and 10 minutes. Got that, Ed?

White Yes.

McDivitt We didn't switch to bio-med recorders. I made a note here early in the flight plan on the bio-med recorders, "Ed slept first and turned no. 1 off." When I slept, we forgot to turn it back on, so we had no. 1 off, and no. 2 on for a long time, for a period of about 8 or 10 hours. Then when I went to sleep the second time, we turned no. 1 on and no. 2 off, which is the way it should have been. But as soon as I woke up, we turned no. 2 on again and no. 1 off, because you were going to go to bed. Now you didn't go right back to sleep again so I have a note here, "We have to turn on no. 1 as soon as he wakes up." We did. Ran no. 1 for awhile with no. 2 off. We turned them both back on, and left them running for the remainder of the flight. What we did is that we picked up a cushion of about 8 hours on each recorder and let them run the rest of the flight. The D-8 Experiment at 2300 hours-- Ed was asleep then. I told them that Ed was sleeping and couldn't make it.

White Right. I think I probably did that later on.

McDivitt That's right. Remember we discussed that you would turn on the experiment later on when you went through the South Atlantic Anomaly?

White Right.

McDivitt You plotted it out on the map and turned it on yourself. The portion of the flight plan at 31 hours elapsed time says, "Prepare for S-6 Experiment, update D-8, MSC-2 and-3 on." Now I turned MSC-2 and-3 on again, about then. We did not do an Orbit Nav check, run 3, because we didn't want to use any fuel. We scrubbed Experiment D-8, and we were going to turn it on at 23:00 or do it at 23:00. But I guess Ed was still asleep, so we didn't do it then. At this time we were both in pretty bad shape as far as rest went, so I felt it much better to get some sleep than to fool with the experiments. Then going through--

White Okay, this is the period of time when you were asleep.

McDivitt Yes, because I don't have any notes there. Go ahead.

White Right. I had a very busy time shortly after I got up. I had a requirement to, at 00:15, --

McDivitt Oh, yes. They called the update to me and I passed it on to you, and then I went to sleep.

White That's right. I turned on the MSC-2 and-3, and then I went D-8 at 02:15.

McDivitt 00:15 Greenwich time, you were supposed to take some pictures of cellular clouds. No fuel allotted.

White I think I took some pictures of clouds.

McDivitt MSC-2 and-3 were supposed to go on at a G.m.t. of 00:30, and you were supposed to control the spacecraft to BEF for that pass.

White That's right, and we went with BEF for that pass, for MSC-2 and-3 experiments. At 02:15 I was supposed to do D-8.

McDivitt That's right.

White I did D-8 at 02:18, as a matter of fact, and it's logged in the D-8 card.

McDivitt Then at 22:35 G.m.t., we were supposed to do S-6--I see that I've got a scratch through it. I think that you weren't up. I was up and I tried to do it, but there weren't any clouds around. I wasn't pointed in the right direction, so I just scratched it out.

White Yes, this is where I went back to sleep and you got up. We had a very important tape dump at 03:03. I think I relayed that to you before I went to sleep.

McDivitt Yes.

White I must have really snoozed here. I was gone for 4 hours.

McDivitt I'm on 36 right now. We had a tape playback. We were eating along in here, and I can't tell you where we ate because we ate whenever we felt like it.

White We always ate when we woke up, and usually before we went to sleep.

McDivitt That's right. That's when we were eating and that's when we had originally planned on it. That's the way it went in the original flight plan. At this time of the mission I guess we weren't doing much except staying alive. My impression of what we were doing was eating, sleeping, and dumping tapes.

White --and looking at the ground as it went by.

McDivitt As a matter of fact, we were still pretty well pooped out from that long period right there--

White Your eyes were just getting better. Your eye looked lousy at that time, the first 24-hour point. Your left eye was as red as can be.

McDivitt At about 36 hours it was still pretty bad, but from there on it improved continuously.

White I noticed that whenever I slept, I got much hotter when I had my faceplate closed and my gloves on. Remember? I kept turning on the double fans.

McDivitt Even when you didn't sleep in that configuration, you got hotter when you slept than when you were awake, which is the reverse of what I figured it would be. I figured that when you slept, we'd want to go to one fan all the time.

White Well, I slept good when I had my visor open.

McDivitt Did you? The last day or so, though, we had two fans on every time you slept.

White The last day we did. Of course, I slept the best then too as a matter of fact. After the first day, I had my faceplate open more often than I had my faceplate closed.

McDivitt I wasn't. I had a problem that when I'd put my visor up, I was really crunched down in the seat, because I'm quite a bit taller than you. It was more comfortable for me to keep my visor down than it was to keep it up. We had an RKV tape dump, around 36 hours, and I have an Orbit Nav check run 4, here. I don't believe we did that, did we, Ed, at 36 hours and 50 minutes?

White I was asleep and I can't tell you.

McDivitt We didn't do any of the Orbit Nav checks with fuel, so it was just a matter if you could see the ground, you did one. They called up some more S-6 information for me, but I wasn't to use any fuel on it. They said I was to pass Typhoon Babe at 06:06, point of closest approach, and there was a new storm brewing. I'd have my closest approach to it at 06:13. Oh, yes. I also have a period that Ed slept here.

White Which time was that?

McDivitt Well, you got up at 08:15, Zebra time. That's about 40 hours and 30 minutes elapsed time. I drifted around to where I could see Typhoon Babe, but there wasn't anything to take a picture of. There was just a mass of clouds down below; smooth tops and nothing worth even a frame. I got another update that said over Cairo, on the 26th Rev I'd have my closest approach at 07:13:37. It would be 90 miles slant range on the closest approach. Don't use any fuel. We were just supposed to look at it. We did pick up Cairo and Alexandria both. I think you were awake at that time, weren't you?

White It was the tail end of my sleep cycle.

McDivitt Well, you weren't awake then.

White What time was it, Jim?

McDivitt It says 07:18:37. You should have been asleep then. I have in my notes that you slept to 08:15.

White Well, I was like you were. I wasn't sleeping very good the last--quite often, I had my cover up watching out the window. You could always hear everything that was going on the radio, so you knew pretty well what was going on.

McDivitt Well, anyway, Cairo and Alexandria were both clear, but this was the first time we'd seen them and it took a long time to find the targets--the particular target that we were looking for. We could find the Red Sea and we could find the Mediterranean, obviously. You could see the Suez Canal. You could see the river. I had difficulty finding the town of Cairo. How about you, Ed, with Alexandria? You were looking for Alexandria.

White I found that one.

McDivitt You found the town all right, but finding the airfield that we were supposed to take a picture of was pretty difficult the first time. Later on when we'll discuss the experiments, we'll comment on that. It looks like I was asleep here for awhile because I don't have any notes.

White Okay. I have a set here. I was given the first time to take a look at some of the D-6 targets. I had no. 1, no. 12,

and no. 13, and I had all the times for them. I think no. 1 is Tripoli. We'll go over these in a little more detail when we go to the experiments. Tripoli was covered by clouds. Alexandria was pretty good, and I was able to follow it pretty well.

McDivitt Did you take any pictures of it?

White Yes. I took some pictures. Actually, I think we should go back and look at these. I got several passes. This was the D-6 Experiment. No. 12 was Tripoli, and it was covered with clouds. No. 13 was Alexandria, and I took manual pictures with the 20 mm Contarex. I didn't actually see--

McDivitt The 50-mm Contarex?

White No, the 200-mm Contarex.

McDivitt The 200-mm. Hand-held?

White No, I had it mounted. I didn't actually see the airport, but I had seen it before. I was actually looking at the camera when I was firing it, so I--

McDivitt Did you see anything in the ground glass?

White Not very much.

McDivitt Were you trying to track that way, or were you just looking out the window?

White No. Just looking out the window. The point that I brought out is that they gave me four targets. The targets should be far enough apart so that you can actually get set for each one. I had four targets here but I could only use--

McDivitt Oh, that was when you zapped from Tripoli to Alexandria to Tel-Aviv to--

White Tel-Aviv and a whole bunch of them all in a row.

McDivitt You could have a thousand miles between targets to evaluate. You finish one, and you're starting to take pictures of the other ones.

White I had them at 10:61:51, 10:21:50, 10:25:30, and 10:30:15. Well, that was a beautiful row of targets in there but--

McDivitt A pair though or every other one would have been enough.

White And we were still being very parsimonious on fuel and I didn't feel like zapping the spacecraft all around. We had some more updates, tape, and a medical data pass for myself at 45:45. We got the word to delete Translations 2-A. At that time they put in D-9--the first D-9 with fuel.

McDivitt We also scrubbed the horizon scan moonset check at 46:33, or whenever that is.

White Right. It was scheduled with the platform up and we didn't have it up.

McDivitt Also I've got the scanner thruster plume checks scrubbed at 47:40.

White Also a deletion of the ES sensor - ON because we weren't going to translate. So at 54:14 we had our first D-9 Experiment with OAMS.

McDivitt We were both up.

White Right.

McDivitt That was the first one with fuel and the first big disappointment of the experiments.

White Right. It was certainly very difficult to use.

McDivitt This is where we tried to do the dayside pass when we had stars, and we couldn't see past the nose of the spacecraft.

White We didn't get any stars so actually the run was quite short. We were not able to see any stars so we weren't able to do much on that run at all. This is the time we knocked off any more day star sightings.

McDivitt We were supposed to turn on MSC-1 and Acq Aid off for 5 minutes between Tananarive and Carnarvon, I guess.

White Oh! This is where I missed a sleep period. This is where we missed a sleep period. We got busy and ran the D-9 right through the sleep period. Then I got back to sleep at 54:55 to 60:65 elapsed time.

McDivitt Oh, yes. You got about 1 hour's worth of sleep between 49:40 elapsed and 50:20 elapsed, or something like that.

White Right before D-9, I got a little sleep.

McDivitt That's right. I've got a little note in here that says, "Ed got about 1 hour of sleep."

White That's right.

McDivitt We were supposed to do S-5 over the States on rev 32. Start at 17:40. We were supposed to do Apollo Landmark No. 4 starting at 15:00 Zebra on rev 33. That was El Paso.

White That's right. We were both up for that.

McDivitt We did the S-5 Experiment together, and that was the best series of pictures we got on the whole flight. It was really fabulous. We got good pictures both for the S-5 and S-6 on this one.

White They should really come out good.

McDivitt I did the Apollo Landmark Area No. 4. I did the tracking task with it at 19:16:42 on El Paso, and it turned out pretty well. We tried to make a tracking pass on El Paso International Airport, and we never even saw El Paso.

White This was a very big surprise to both of us because we thought we'd nail that one cold.

McDivitt That's right. We've been in and out of there so often, you know, it's just like another home base.

White Which leads to one of your conclusions, which is--

McDivitt You can't have targets out in the middle of a land mass. They've got to be near a body of water.

White You need something to identify the landmark.

McDivitt There are some beautiful topographical features near El Paso. There's a range of mountains just to the west that show up and the white sands are out there to the west--Shoot! We never saw anything. I think I saw El Paso when we were right over it. I said, "I think there goes El Paso. I think we missed it."

White The next thing we said was, "Yes, it is. There's Texas." We could see Corpus Christi coming up on us. That's where you took it.

McDivitt That's right. So then I went to a tracking task on a pair of sand pits, with a channel between them, right on the coast--around Corpus somewhere. So, we did a tracking pass on it because we were all set up and we'd already used the fuel to get stabilized. We were all set to do something so we went ahead and did something. We took some 200 mm pictures of this.

White I took about 10 pictures.

McDivitt We'll just see how the target stayed in sight. This was our first real tracking pass, wasn't it?

White I had one good one on Tel-Aviv.

McDivitt Did you use the fuel required to do it and all that stuff, or did you try to chintz on it?

White I tried to chintz on it, but I think it was good tracking. I actually tracked the airport at Haifa instead of Tel-Aviv. I realized it at the last minute that I didn't have Tel-Aviv, I had Jaffa, but I had an airfield and I had a town so I--

McDivitt You took some fixed-mounted 200 mm pictures.

White Yes. I took about two pictures of it. I couldn't take a series. I--

McDivitt That's right. You didn't have the gunsight to track with either.

White No. I just put it in the middle of the window.

McDivitt At this time our orbit was 88.1 by 148.7, so we had come down about 7 or 8 miles. D-9 and Apollo 4 were around 51 hours. I don't know exactly how that fit into this schedule that we were doing. We were switching back and forth from elapsed time to Greenwich mean time so we got a little confused on these. We got updates of the PIA's and CLA's. This plan says, "Prepare for D-6." Well, we didn't have a D-6 Experiment anymore. Ed went to sleep again at 54 hours.

White Yes. At 54:30 I've got myself asleep.

McDivitt Ed asleep at 54, and I have him waking up at 59:15. That was when we started trying to make you sleep a little longer, Ed.

White Half our notes here are elapsed time and half of them are in Greenwich mean time. I think this is probably one of the weakest points in our flight planning--trying to get times correlated.

McDivitt This correlation between one time and the other time is hard to handle. We were getting start times in G.m.t. We said that we wanted these start times in G.m.t. because this is the only official time that we had. The elapsed times were just for planning. We only kept them to the nearest 2 or 3 minutes. I started my Omega watch on elapsed time at take-off, and I just let it run through the whole flight. I never set it. I never checked elapsed time or anything. It could have been off 2 or 3 minutes, but I was doing the flight plan to the nearest 10 minutes off the book here. When we got retrofire times and when we got start times for things, we got them in G.m.t. It made it awfully confusing in the flight plan by switching back and forth. Fortunately, we got off at 15:15, which is better than getting off at 12:36 or something like that. On the Apollo mission we've got a better set of clocks. We're going to have mission time and phase time, so whenever you start a new phase you go back and start all over again.

White Well, I'm not convinced that we couldn't have even handled this one on elapsed time.

McDivitt We did.

White Well, I mean let everything go elapsed time. Forget about your Greenwich mean time.

McDivitt No.

White I don't know what we would have lost.

McDivitt The retrofire times.

White Put the retrofire time on elapsed time. Like you say, it was much clearer to you using that one watch on 12-hour increments, and it was to me too. That's the one I used. I used this one watch right here on elapsed time.

McDivitt Well, let's get into that as a separate thing at the end. We had the MSC Experiment 2 and 3 off at 02:25. We turned

it on at 22:14. These are Zebra times now. I have a note here, "Perform D-8 Experiment, Radiation Experiment, at 55:30 elapsed time," and I've got, "No. Pilot asleep." Did you do that experiment later on, Ed?

White Which one was that, Jim?

McDivitt D-8 Experiment.

White At what time?

McDivitt At 55:30 elapsed.

White I've got them in Greenwich mean time here again.

McDivitt That's around 22 or 23:00. Something like that.

White Yes. I've got one. I did it at 23:58 G.m.t.

McDivitt How did you do that? You were supposed to be asleep then. Maybe you woke up and did it and went back to sleep.

White You know, this was the time when you went to sleep. I've got you asleep on the fourth day at 03:30 G.m.t.

McDivitt We're not on the fourth day. We're still on the third day. I'm between 54 and 59 elapsed.

White All right. That's the period of time I'm asleep.

McDivitt I've got the D-9 Experiment was run between 22:43 and 23:22. I must have done that. Okay. We got Ed up at about 59 hours elapsed time, and did a medical data no. 2 pass on me, except by then I think they were medical data no. 1 passes. I went to sleep at about 60:15 elapsed, and I got up about 65:30 elapsed. I had about 5 hours there when I was supposed to sleep.

White Shortly after you went to sleep, we started having the RCS heater troubles and we had them coming on for the next 3 to 4 hours. We had them cycled on and I called the times down. I don't believe we want to go over them all right now. I had them cycled on and off at intervals of about 15 minutes, for a total of eight different times. They started coming on exactly at 06:47 and the last one I had was on at 08:23. That was the last time we had any RCS heaters. It was rather peculiar because they alternated. First the A-ring would

come on, and the B-ring would come on, and the A-ring would come on, and so on.

McDivitt Is that right?

White They came on at approximately 15-minute intervals and it took approximately 5 minutes to bring the temperature down to within limits. I reported those down, and they seemed to be interested in getting exact on/off times of our heaters to plot our electrical profile curve. I ran an Apollo Landmark Run No. 6 with yaw 15 and pitch 30. I think the results of that are in the other logbook. I reported down at this time that Jim had a successful bowel movement. I already had one. I had an HF check at Ascension at 05:09, which didn't work out--

McDivitt How could I have a successful BM if I was asleep?

White You had already had it. I reported it at that time. I wasn't able to read Ascension on this HF check. I got the okay for an Apollo D-9 Run No. 2 for 06:01:44. I called down to get clarification on it, and they said I could use stars of opportunity. This is what I did. I ran the D-9 with the stars of opportunity. Why we did this will be brought out in the D-9 debriefing.

McDivitt This was a no-fuel D-9?

White No. This was with fuel. But, remember, the stars were placed so it was hard to get much.

McDivitt Yes.

White We scrubbed the Apollo Landmark Investigation No. 1. We didn't do that. We gave a medical data pass. Ran the D-9 Experiment, I believe, and got fairly good information back on that. As a matter of fact, I did do the Apollo Landmark No. 6 and that information is in the flight log. I got Jim up, it says, at 08:31. This doesn't sound right to me.

McDivitt I got myself up around 65:40 something elapsed time. I just drew a mark there.

White That's exactly where I've got you up--at about 65:40.

McDivitt I got a comment here. This is something that went on throughout the flight. I went to sleep and I looked at the OAMS

quantity gage, and it was reading 60 percent. When I woke up, it read 56 percent. This meant a 4 percent drop, and it was somewhat alarming since we were saving fuel so much.

White — He accused me of having to use all the fuel up while he was asleep. Ha, Ha!

McDivitt — No. I'd noticed that the gage went up and down before, but it never had gone up and down so much in such a short time. It would move up and down by 2 percent quite frequently over a period of 15 minutes to an hour. It would change by 2 percent. It did this between 60 and 70 percent for a long, long, long time. We were going pretty easy on the fuel. It did move up and down like this quite a bit. This is just a comment that throughout the flight the OAMS quantity gage did fluctuate quite a bit. We had the uncertainty in the system and this 2 percent was, in general, about 7 pounds. That was really quite a bit of fuel. Four percent was between 12 and 15 pounds, depending where you were on the scale. This was an awful lot of fuel to have suddenly disappear. I just wanted to comment on that. It was an interesting thing. We'd been dumping our ECS O_2 pressure. We'd gone to high rate or cabin repress and dumping the stuff overboard--overpressurizing the cabin and having the cabin vent to keep the pressure down. Finally around this 66 hours, we'd dumped the thing down to 880 psi on the gage. This was why we didn't have to dump it so often. We'd been dumping it before around 960 psi--dump it there and bring it back to around 930 psi and let it build up, and then repeat the cycle again.

White — That was about every 4 hours.

McDivitt — Yes. We had to dump at least every 4 hours. We brought it down to 880 psi, and this gave us a period of around 12 hours.

White — You know, I thought this was a very clever method of holding the cabin at a higher pressure than normal by McDonnell--putting the vent down so low that it vented in a normal mode. You certainly could tell on the gage when it was going to vent. It vented right down there at about 960.

McDivitt — Yes. I thought we'd really hack that apart when we got to the systems.

White — Yes. All right. I wanted to be sure that we didn't forget it.

McDivitt I guess we were both awake at this time. We did MSC-10 some place. Here's where we got into a bunch of bad flight planning. Someone on the ground screwed up.

White They ran our horizon scanner and MSC-10 checks right together.

McDivitt We started out our MSC-10 check, and, at the same time, we were supposed to start powering up the platform and alining it.

White What time did you have MSC-10 experiment?

McDivitt We were supposed to power up the platform at 10:15. Let's see if I got the start times here for MSC-10.

White We'd have it in the book.

McDivitt Well, we didn't get a start time because MSC-10 starts when the horizon comes into view, when we could see the first light. We started the MSC-10 as a sequence of pictures every 5 minutes. The sequence is three pictures every 5 minutes, for as many passes as you can get. So you have to start this thing at sunup, or as soon as the horizon becomes light. We took our first three pictures. We went on through, and we were supposed to start our horizon scanner check--.

White Jim, the time we started you've logged in here as 11:04.

McDivitt Okay, at 11:04 we started our MSC-10 Experiment. We were given instructions to start the horizon scanner sunset check at 11:54. It just so turned out that we were going along and we weren't out of frames of film yet for MSC-10.

White It was still daylight.

McDivitt Yes, it was still daylight, that's right, and we could still get some more good pictures, I thought. Here we had instructions to start our horizon scanner sunset check, and in looking through this thing, it looked to me like that was the only place we were going to get it; so I don't understand exactly why we had to run MSC-10 and the horizon scanner check simultaneously. They couldn't be run simultaneously! It looked like somebody with a little foresight on the ground could have seen this.

White That was really the only bad screwup, I think, in our flight planning. It was right there.

McDivitt I think so, too. So we terminated MSC-10, although we had enough pictures, I'm sure, to have completed the experiment. It would have been nice to use up all the film. There's no sense in carrying it and not using it. At 11:54 we did the horizon scanner sunset check--the platform up and alined. At 12:15 we did the horizon scanner moonset check. At 12:22 we did the Apollo yaw orientation. At 12:58 we did the horizon scanner thruster check. At 12:59 we did the horizon scanner track check. At 13:14 we did the attitude thruster check. At 13:20 we were supposed to power down and at 13:20 were supposed to turn off the MSC No. 1 Experiment. What happened as we went through here--we got a little behind because it took a little longer to do some of these things, especially this horizon scanner track check. It was taking so long that we eliminated the last two steps in it. We did the zero bank angle and the pitch up and down. We did the zero pitch angle and the roll left and right. We did the bank to one side and the pitch up and down, and we did the pitch up and the bank on both sides. We didn't do the pitch down and the bank on both sides, and we didn't do the roll left and the pitch up and down. We were running late and at that time I didn't know how we were doing on electrical power and everything, so I elected not to do the last two portions of the check.

White We had it pretty well ironed out, anyhow.

McDivitt Yes.

White Surprisingly broad bands, too.

McDivitt The scanners seemed to be working perfectly. The attitude thruster check was just as it should have been. We powered down the platform and turned off the MSC Experiment No. 1 about 2 minutes late.

White We powered down at 13:27.

McDivitt Okay, 7 minutes late. We never did take any 16 mm photos of the plumes.

White Before you went to sleep on this one.

McDivitt I hadn't gone to sleep on that one.

White Before I went to sleep.

McDivitt Before you went to sleep, yes. Okay D-9--

White We were really busy at this period of time.

McDivitt Yes, a D-9 at 20:51 Zulu.

White I have a feeling I was asleep here, Jim.

McDivitt I think you were, Ed. You went to sleep at 71:15.

White 71:15?

McDivitt Right. I did the D-9 Experiment at 20:15.

White At what time, Jim?

McDivitt At 20:15.

White So you did the D-9 while I was asleep.

McDivitt I have a note here that we're going to be over Guaymas at 15:44:55. They wanted a no. 1 medical pass from me. They wanted me to turn the TM switch to REAL TIME and ACQUISITION for 3 minutes over Guaymas. Guaymas must have lost its command function or something--not for the whole time though.

White Yes, this is where I was asleep, Jim. I remember that now.

McDivitt Okay, now I have a comment here. I turned on our horizon scanner at 16:03 with about a 25° nose-down attitude, with a pitch-up rate of about 2 deg/sec, in the horizon scanner mode. The thing caught and held the spacecraft within the deadband and finally damped it down, and we stayed in the horizon scanner mode. I think that this is about the time that we went to horizon scanner, isn't it?

White You were in horizon scanner while I was asleep.

McDivitt Yes. I don't have that in my notes, but we went in the horizon scan mode around 72 hours, I think. I think it was at 16:03 G.m.t. that I mentioned it. I didn't do an Orbit Nav check at the 72 hours and 50 minutes as shown in the flight plan. Oh, here's where you were up again, Ed. Because you were up when the computer screwed up, weren't you?

White Yes. I saw the light.

McDivitt Okay. During the course of our passes over the States, here, around 75 hours, I was told to do Orbital Nav check no. 9 at about 75:30, and I was to do Orbital Nav check no. 10 at about 75:50. Okay. I completed the Orbital Nav check, run no. 9, and then you must have waked up, I think. I think you were asleep when I did that.

White What time do you have me waking up? I know about what time I woke up.

McDivitt You woke up around 75:30 or so. I was going to do an Orbital Nav check no. 10, and we were over the States. They wanted us to turn on the computer to send us a load, so I did. That's probably what woke you up, when I was trying to turn on the computer with the swizzle stick.

White Yes.

McDivitt But this time the computer stuck in the ON position.

White When you tried to turn it off.

McDivitt And it wouldn't go off.

White I remember watching. I saw the mal light go on.

McDivitt So it stayed on, and that's when we had all of our computer trouble, which you'll check and cover in systems. Oh, the time the malfunction light came on was right when we were about to turn it off.

White I'd say around 75:15 or something. In that area?

McDivitt 75:50 CSQ-Hawaii. I think it was about 75:50 or thereabouts. They sure do have some peculiar times here. It only takes, according to flight plan, 30 minutes to go from Guaymas back to Guaymas. That's a high speed orbit.

White That's right. It does have that, doesn't it? Looks like a food, doesn't it?

McDivitt It only takes 40 minutes to go from Hawaii to Hawaii. We were really traveling! I don't know what time the computer stopped.

White I think they've got it on the ground. They can read the mal light.

McDivitt We were talking to them on the ground. It should be on the air-to-ground tape. Then we were cleared to do Apollo D-9 in the orbit that covered the night time around 77½ hours or so.

White That was my D-9 at night, wasn't it?

McDivitt That's right. Ed did this.

White Before you went to sleep, though, we had one other thing. We had the zodiacal light photographs that we took, and we had a special procedure called up where we pointed straight down.

McDivitt Oh, yes. That's right.

White Pulsed it, with the shutter speed of the Hasselblad open. You operated the Hasselblad and I operated the spacecraft. We pitched down and ran through this test and pitched up and ran through--

McDivitt The Contarex.

White You used the Contarex. That's right.

McDivitt We did this at about 78:30, and I went to sleep at 79--

White No, we didn't. We did this at 76:30, Jim.

McDivitt 76:30? I have 78:30.

White I just took on rev 51. You're correct. That rev 51 they called up wasn't right. Okay, we did it at 21:40, which I have as equivalent to 78:25.

McDivitt Then at 80 hours I went to sleep.

White You went to sleep about 80 hours elapsed time. That's right. Okay, while you were asleep, I ran a D-8. In fact, I had quite a bit to do while you were asleep this time. I ran a D-8 at 23:57. These are all Zulu times. I turned on the MSC-2 and 3 at 23:57. This is where I had the requirement to attitude hold, small-end-forward, through the anomaly. On the first pass through at 23:57 to 01:30, I didn't feel that I had a good attitude. From 23:57 to 01:15 I didn't feel my attitude small-end-forward was satifactory. I elected to make a similar pass through on the following orbit,

watching the stars and making sure that I had a good small-end-forward. I found out that the first pass through was pretty good until the tail end, where I thought the stars were in the wrong position. It turned out that this is just the way they came up, and I was good for both of them except for the tail end of the first run through, I logged in two small end passes through the South Atlantic Anomaly. I also ran the D-9 Experiment, and I found that by using the fuel and having the horizon scan to hold when you wanted it to hold, the use of the sextant and horizon in making measurements was considerably easier. I made what I feel was a good Apollo D-9 run. I ran the D-8 Experiment. I had two times to run the D-8 Experiment. I ran it at the G.m.t. of 01:30. I was to look for Pegasus at 02:28, straight up at 268 nautical miles, and I was all hot to watch Pegasus go over and was just approaching my straight up attitude when--

McDivitt The sun shined on the window.

White No, I was called and they said, "Say we got a critical tape dump. We want you in a level attitude for it." And I said, "Well, you just gave me instructions to watch Pegasus." And they said, "No, we want the critical tape dump." So I went right down to that attitude, and we got the dump off in time for me to go back up to the attitude prior to 02:28. I got up there about 5 minutes prior to that time, but the sun, as Jim said, was up and was reflecting off the particles on the windshield, and I really couldn't see very much. I tried to see Pegasus, but I couldn't see it. I turned MSC-2 and 3 off at the appropriate times. We got instructions from Houston CAP COM to try a few things with the computer. We were to turn the computer off, the IGS on, the computer on at 20 minute intervals to try to recycle the mal light off. They thought that it might have been cold.

McDivitt Let me step back a little bit to this computer problem. The computer stuck over the States at around 75½ hours or so. The computer was stuck on. If you've got to have something stuck, you're better off to have it stuck on, I guess, than off. Especially if you ever want it to work again. As we went out of earshot of the ground UHF radio range in the States, I asked them if that they had any instructions. They said, "Stand by." I sort of felt that the thing that we ought to do was just leave it on for a while. We got a call from Tananarive, and they said to place the computer switch to the ON position and ac power switch to the ACME. I said

that's certainly a peculiar place to put the switch, and they said these are the instructions from Houston.

White I think we had a good computer at that time.

McDivitt I know darn well we had a good computer at that time. I think this is like getting your landing gear stuck up, and you fool around with it and it comes down; and then, just for the hell of it, you pull it up again to see if it's going to come up. I don't think we should have ever turned off the computer. Unfortunately, I didn't have all the information at my fingertips that I needed to really make a decision on it. When we got to the next station, which was Hawaii, I asked them how we were doing on electrical power. They said that we were 160 amp-hours ahead of the curve. We had a 200 amp-hour pad cushion, so that meant that we had a 360 amp-hour pad on our flight plan. In the meantime, I had checked to see what the computer-ON, IGS power supply-ON took. It took 5.6 amp-hours to power this thing. We were at 76 hours on a 96-hour mission and we had about 20 hours to go. Twenty times 5.6 is a little over 100. So, if we had used up these 100 amp-hours, we'd still finish up with a better electrical pad than we started out with, or than we expected when we started out. So, I sort of feel that we needlessly threw the computer down the drain. After we got the thing turned off and ruined, we went ahead and turned the IGS power supply on, the computer on, and left it on the rest of the flight anyway. So, whoever sent those instructions accomplished it. I guess what he wanted to do was turn off the computer. He sure accomplished that. It seemed to me like it would have been more worthwhile to leave the thing on till we got a little more data out of the thing, instead of rushing to get it turned off the way they did. I don't understand it. I don't feel that it was a wise decision. Unfortunately, I didn't have the electrical power consumption at my fingertips right then, or I never would have turned the thing off.

McDivitt Okay, I guess we're over about 86 hours. I got up at 86 hours. That's one of the longest rest periods that I've had. At 05:48:45 Zulu we were supposed to perform a D-9 Experiment. And I guess we did. Then I have in my notes that Ed went to sleep at 87 hours elapsed time.

White And this was my 5 hours of very good sleep. It's my best and last. You must have let me sleep till when?

McDivitt I don't even have when I got you up, but it was about 5 or 6 hours. I think it was around 6 hours.

White No, it wasn't that long, was it? Because that would have run us a little short. You had about an hour 45 minutes or two--

McDivitt I had an hour and a half nap. I got up at 5 hours before retrofire. Retrofired at 97:45. I went to sleep at 93 hours.

White Okay. So, I got up--

McDivitt Ed got about 6 hours nap.

White I got up about 95:05 that time. You went to sleep about--

McDivitt No, you went to sleep at 87 hours and got up at about 92-- a little past 92.

White That is what I'd estimate, Jim.

McDivitt A little past 92. So, you had about a good 5 hours. I know that you were still sleeping at 92, because that's when the urine system stopped up, and you were asleep then. So, I think you got up--I'd guess, around 92:30. I know I went to sleep at 93. I went to sleep in p.m. G.m.t., and 15 after the hour, whatever the hour was, and I woke up again. During the time that Ed was asleep, I did two Apollo landmark runs using area no. 16 for the first one. This was on Basra. It was a good run. We'll go into this a lot more in detail later on. I did the second one on Cairo. This was a good run. I went through some more computer mode checks. Every 10 seconds, I changed the computer modes and turned the switches on and off, pushed the malfunction lights, hit the start comp button, turned the switches on and off, ran the IVI's and a whole bunch of other things. The computer was dead, and it was pretty obvious that it was. At 92 hours, the urine flush system stopped up. Just prior to that Ed had urinated and we had a big bellows full. As it started going overboard, it always went overboard in squirts.

White Did you have it at 92 or 93?

McDivitt 92.

White Okay, that was when I was asleep.

McDivitt You were still asleep, and I think you got up around 92:30, I would guess. Sometime around in there. I know that I got up 3 hours before retrofire and I slept about an hour and a half. You can go back and say that you got up about 92:30 or 93 elapsed. Ed had urinated in the bladder and the bellows was full. As it got towards the end, it started going out very slowly, but it did all go out. So, I turned the thing off normally. I left preheat on for a short time, 2 or 3 minutes, and then turned it off. After my urine dump, I had about half air and half urine in the bladder, and the bellows filled out. It just stopped. It was pretty obvious that it wasn't going to go any farther. I turned off the OVERBOARD position and went to PREHEAT on the other switch. I then went over to the evaporator and dumped through the evaporator and it dumped right overboard. We used the evaporator dump system one other time during the flight. We played back the tapes and the things we were supposed to do until about 93 hours, I believe, and that's when I went to sleep. I woke Ed up, and I went to sleep at this time.

White Actually we got our update while you were asleep the time before. We got the update for how to perform the retro. We figured that with the procedure they gave us, if we followed it, we would get a 3-σ miss distance of 70 nautical miles. We were to use an OAMS retro with a manual retro. At this time, we were going to push the manual button. They didn't know at this time that the TRS was working all right. They later came in and told us to use the automatic mode of time. We were to use zero-lift rolling. We were to start the terminal maneuver at the 400 000 foot marker. They told us to expect to encounter about 8g during the reentry. We were told the recovery area had 3 to 4 foot waves, 18 knot winds, and good weather. I'll cover this more later.

White There wasn't much more. We got an update. I took a few more pictures, and I did a medical pass. During that hour and 40 minutes there wasn't anything else. Nothing else was scheduled. We were down through what we felt was all the fuel we wanted to use, so about all I did was a couple of tracking tasks.

McDivitt Going back for a moment--at 17:19 I did an Apollo D-6 on Yuma. Okay, I think that brings us to the preretro portion of the mission. Right, Ed?

White Yes, sir. I think you'll find there are quite a few errors and omissions in what we've put on the tape right now. I

think you have to compare them both--the two tapes together--to get anything.

White That's like air-to-ground tape, also.

McDivitt That's right. It has to all be put together. This is just a piece right here.

4.4 Preretro Preparation

McDivitt We really started our preretro preparation about 3 hours prior to preretro. At this time we started stowing equipment and preparing the spacecraft and ourselves for the retrofire. I think we worked for probably 30 to 45 minutes without making a very big dent in the pile of junk that we had in the spacecraft. It was apparent to me at that time that we were going to have to go a lot faster than we were going or we'd still be up there stowing stuff away at retrofire time. So Ed and I then went into high gear, and we really started stuffing stuff away. We put the film in the middle food box, and we put the cameras and some of the refuse, including three defecation bags, exerciser, and some other things, in the left-hand aft food box. I took a lot longer to stow the equipment than we had planned. Do you have any comments on that?

White Yes, I thought this also. We had just everything out prior to this time. We hadn't really been able to stow anything. We used every piece of our equipment right up to the time we started our stowage. In fact, I think you were getting a little uneasy there for a little while that we weren't going to get it all in.

McDivitt That's right. At the rate we were going, we wouldn't have.

White That's right. We had to accelerate our pace a little bit and perhaps get a little faster and not quite as thorough in our stowage as we would liked to have been. I think everything was put away. Everything was put away except for the umbilical. We knew we weren't going to stow the urine hose, so we put that in the umbilical bag. The two meals that we had left we put in the umbilical bag also.

McDivitt We had some other things. We had the extravehicular sleeves off your suit, the blanket that went over my leg, the launch-day urine bags, and a couple of other things were down underneath my legs. They were between my legs and the seat.

White Right. I put my launch-day urine bag in the bag also, so that things wouldn't ricochet around.

McDivitt I think we had all your stuff in the bag and I had all my stuff wedged between my legs and the seat.

White We both also had a trash bag on either side. We had that on the launch also.

McDivitt The trash bag was full.

White Did yours stick on the side?

McDivitt It stuck.

White So did mine. I put mine further up--

McDivitt It didn't have anything heavy in it. It was light weight.

White It was all trash.

McDivitt Dry trash.

White It all stayed there pretty well. We did get the stowage done in time. I think we had about 10 or 15 minutes in which to collect our wits for the--

McDivitt That's right. I was trying to make an effort such that at the time we arrived over Carnarvon the greatest part of the stowage would be done. However, we didn't quite make this. I had a time powering up the spacecraft, and I had the IGS power on. I had already turned the IMU on. I was beginning to warm it up, and had it in the cage mode.

When we got to Carnarvon we were still stowing things away. I think by that time I had already strapped myself into the spacecraft. I had my survival gear hooked up, my shoulder harness hooked up and my lap belt on loosely.

White We did the things that I could do by myself, such as stowing the ventilation module and stowing the cable. You were doing other things.

McDivitt That's what I said. We were coming up to Carnarvon. I was shooting to have all this stuff put away by then. We didn't have it all put away but we had most of it done, where I could actually get around to flying the spacecraft again.

We checked in with Carnarvon and confirmed our retrofire time. We weren't really supposed to pick up our retrofire data until we passed over the States. From Carnarvon on up to the States, we continued to stow away little bits of pieces that we had. I think we were still eating. We finally decided that you'd better stop eating or we weren't going to be ready for reentry.

White — With a little prethought I had taken one meal, prepared it, and set it aside so I could eat it just before reentry. This is what I was doing.

McDivitt — As we came up on Carnarvon, I thought that we were in excellent shape. We had a lot of spare time. We could get ready for retrofire. We came up to the United States and ran a pass across the United States. We got the update times and we got all the reentry quantities that we needed, both with and without OAMS. They told us that they had a valid load in the TRS. At this time, I assumed that they checked the TRS, but when we got our early retrofire, I wondered if anyone really had checked the time.

White — I know it was off at least a second. I'd estimate it was off a little more than a second.

McDivitt — A second and a half, probably. No more than 2 seconds because we didn't arm it until 3 seconds. But it sure fired shortly after that.

White — Yes. One thing that we got was different. All our quantities checked out except for one. They called up a landing time which, the first time, I copied it as 15:55, and the second time I copied it as 17:10. This was prior to firing anything, so I think they corrected one time only. I thought the rest of it was very well handled. We had the times called up and verified several times.

McDivitt — As we started our pass across the States, I started alining the platform. We had the best alined platform, although we didn't really need an alined platform since we didn't have a closed loop guidance system. But we sure had the best alined platform at retrofire that the space business will probably ever see. I alined the platform across the United States, and then I went to orbit rate. I had about a 20-minute alinement on it and went to orbit rate. We left it in orbit rate. I did this alinement small-end-forward because I wanted to see where I was going for a change. We went into the dark side, and we really got into our

checklist then. We performed the preretro checklist well in advance of when it was supposed to be done. It shows it in the flight plan at about 96:40 with the retrofire at about 97:45. I think we did the retro checklist right after we completed our pass across the States. We did it right at about 1+30. Then I did it at 1 hour. At T_R-1 hour we went through the checklist again, and got all those things that we skipped. Some of them we didn't want to do as early as an hour and a half. We went through it again in an hour, and we did the preretro checklist step by step. I think at that time we had everything stowed away. We took a couple last drinks of water, and put the water gun away, and then proceeded on down.

White I had one comment on that checklist. I still think our HF procedures are not too well defined--when we do and when we don't put the HF out. Not out, but when we put no. 2 on HF. It popped up in the checklist again and we questioned this prior to the flight. Why put no. 2 audio on HF during this time? I do not feel we want to be on HF. We had the HF on. We could hear them calling us, if they did call us on it. We could switch over to it quite quickly. This wasn't on the checklist, but we put my switch on RECORD and recorded the whole sequence of events.

McDivitt That's right. I think that was sort of a needless position. You could listen on HF without having the transmitter on.

White That was the only discrepancy that I found in our checklist. Everything else we went through. One other thing. They had, "Insert a new voice tape," and we both felt we wanted the full reentry on one tape. If we put a new voice tape at this time we wouldn't have gotten it. So I inserted a new voice tape at the -36 checklist, and I think this is a good time to do it on future flights.

McDivitt Yes, the T_R-36 checklist was to be done over Carnarvon. We decided that we would check the maneuver thrusters prior to Carnarvon since we had a lot of time. There was no sense in waiting until the checklist time came around. Since we had a lot of time, which was the thing I was striving for, I went ahead and checked the aft-firing thrusters no. 9 and 10 as we had in the T_R-36 checklist, except we did it between T_R-45 and -40. Got them all checked out, so that by the time we came over Carnarvon we just went ahead and started up our event timer on their mark. We confirmed with Carnarvon that

we had indeed checked on maneuver thrusters, and that they were all right. We got this checklist completed well in advance too. We went through it a couple of times, although there really wasn't much to it after the maneuver thruster check. I guess we could probably follow the retrofire itself here.

5.0 RETROFIRE

5.1 T_R-36 Events

McDivitt I just covered most of this. I set the event timer up well in advance of Carnarvon. At Carnarvon, I got the T_R-36 hack. I got the event timer started right on the money. We got a hack on it later, and it was indeed with the ground times. I checked the aft-firing thrusters prior to reaching Carnarvon, and I told Carnarvon that I had indeed checked them and they were operating properly.

5.2 T_R-22 Events

McDivitt At T_R-22 I was alining the platform. I started alining the platform over the States, and I put it in orbit rate for a while. Finally we got over to the dark side and there wasn't anything else to do, so I alined it some more. I alined that platform for an hour and a half. We had the best alined platform at retrofire in the world. We were in pretty good shape by the time we got to the T_R-22 checklist, which is really nothing at all. It's just another platform alinement. We checked our ground updates, and again Carnarvon told us that we had a good load in the TRS.

5.3 T_R-13 Events

McDivitt At T_R-13 minutes we started the computer. We started our T_R-13 minute checklist at about T_R-14 to make sure we didn't run into any problems. We got into orbit rate, and I got all the things out just like the T_R-12 checklist says. We had an OAMS burn of 2 minutes 40 seconds. They called it up and I checked it. I was exactly right. They were obviously flying it off the same card that we were, because I checked it and it was exactly 2 minutes 40 seconds.

5.4 T_R-12 Events

McDivitt Hawaii said they would give me a countdown to T_R-12, and they gave me the 3, 2, 1 Mark. I started thrusting at that time. Ed had planned to give me a check at 1 minute elapsed time, 2 minutes elapsed time, and at 30 seconds to go, 20 seconds to go, 10 seconds to go, 5, 4, 3, 2, 1, and off. That's exactly what we did. He called me at 1 minute, and again at 2 minutes. We went right on down, and he gave me the Mark. I was checking the time as he gave me the counts. It was agreeing exactly with my event timer. At Ed's Mark, I released the attitude controller and we were within tenths of seconds of exactly 2 minutes and 40 seconds of burn time. During this period of time, I think I held the attitudes probably within plus or minus a degree. It was very easy to control. The thing that I noticed most about it was the absence of noise from the aft-firing thrusters. I could hear the RCS firing, but I could not hear the aft-firing thrusters.

White I could hear them.

McDivitt You know how the "x" is like this? My ears were plugged up throughout the flight, so maybe you could hear them.

White I could hear them.

McDivitt That was in rate command.

White And stopping?

McDivitt Yes, I heard rate command. I knew what I was doing with the stick. Maybe what you were hearing was rate command.

White I was going to comment that the way that I was listening to them, I thought they were just cutting out.

McDivitt You were hearing the attitude thrusters, Ed. Here's what would happen. I would be thrusting along and the thing would start deviating. It had a tendency to deviate more in yaw.

White Is it continual? Did you hear it all the time?

McDivitt Yes, almost all the time except for pauses that were frightening, as the attitude would drift off just a slight

amount, around a degree. It wasn't deviating a lot so I was making small corrections. It would deviate in yaw so I would control it back. It tended to deviate slightly to the left all the time. I controlled it over to the right and I would bring the ball back underneath the dot. Then I would even go back to zero. Then I would release it. I would bring the stick back to neutral, and for a short time, the rates would build up and the silence would be deafening. There would be no noise whatsoever. I would think, "God bless it. Have the aft-firing thrusters stopped firing?" Then the thrusters tended to yaw the spacecraft some more. As it came around, it got past 0.2 deg/sec deadband, and the rate command started firing again.

White Okay, that's what I heard. That's right.

McDivitt That was rate command. When I yawed back around, it was really going. I'd come back to neutral and it would stop.

White All right. Then I couldn't hear them. I didn't hear them when we took the check on them.

McDivitt Neither did I. I didn't hear a thing. I agree 100 percent with Gus that you absolutely can't hear these aft-firing thrusters.

White My ear muffs are loose. They are always loose on my ears. So if you could hear it outside, I would have heard it. I didn't hear it. I heard rate command.

McDivitt Those attitude thrusters really make a noise.

White They make a big noise. It sounded to me like I could hear the thrusters firing and I was also detecting these pauses every so often. Several times I thought, "Oh heck, it's stopped!"

McDivitt That's right. Especially, when we started getting down towards the bottom. The old fuel gages were going down toward zero and the time was running around. It looked like it was going to be a dead heat between which went out first. There was one particularly long pause at about 2 minutes and 30 seconds. I thought, "There it goes," and we made a quick correction. And when I stopped, I couldn't hear a thing. Nothing changed. That's all it was.

White Okay. I retract my statement.

McDivitt Well, not knowing exactly what I was doing with the hand controller, you--I was making small corrections.

White That's the first time I'd heard that kind of a sound.

McDivitt We were getting it when we were chasing that thing around, too--when we were chasing the booster around.

White You were thrusting again. I thought this was the other one.

McDivitt Yes, that's right. So we got through the T_R-13 and T_R-12 checklists. The T_R-13 and the T_R-12 checklists really should be grouped together--the preparation and the OAMS retrofire.

5.5 T_R-5 Events

McDivitt Once more we started doing our checklist a little early. Since we had the time there was no sense in wasting it and then rushing at the end. So we went through what we could in advance of T_R-5. The things we couldn't do or that didn't need to be done in advance we waited for until exactly T_R-5. I guess this is where Ed got the first clue that the TRS was ahead of the ground time.

White This is an area where I particularly watch the time. This is an area where I'm making a time check to start the elapsed timer going in order to get our time after retrofire. I was watching it pretty close. The indication on my watch was that the TRS was about a second or so early. I felt we had a good G.m.t. hack. We checked it several times and I thought we had a good one. With my time reference it was approximately a second to a little better early. At this time I had about half of the checklist completed before we got to the time for it. I verified it several times. It's not a hurried time at all, from 36 down, I don't believe. There's no time in there when you're really rushed unless it--.

McDivitt Yes. It is not hurried, provided you have everything else completed and you're not doing anything else but preparing for the retrofire--you have nothing going wrong during this period. At T_R-5 the sequence lights came on a little bit early and that's where Ed got his first clue that the TRS was ahead of the other thing. I didn't notice it because

I wasn't watching my event timer that closely. Ed got his G.m.t. stopwatch started. Why don't you go ahead with the electrical, Ed?

White I turned the main batteries on, verified them on, and verified they were taking the load. They were in good shape.

McDivitt This is where we turned the OAMS off and the RCS on. Let me talk about the checkout on the RCS now. We had armed the RCS prior to the T_R-56 checklist and checked out each ring.

When I was checking the rings out, I felt that I might have a thruster out. That was because when I pitched up or down, my top left yaw thruster was firing in one ring. I felt that I might be generating a rolling moment by having one of my pitch jets out and the yaw jets were having to take out this rolling moment. I checked it in one ring. I don't remember which ring it was. I went to Direct and did it again. I didn't seem to do it, but on the other hand, it didn't seem to make the spacecraft roll either. Then I turned that ring off and went over and did it on the other ring. Identically the same thing happened. I thought I might have trouble with the roll gyro. I turned the roll gyro to SECONDARY. That didn't seem to make any difference. We went back to PRIMARY. I remember commenting at that time that the RCS was a lot looser in control than the OAMS. It seemed to me that the OAMS held the spacecraft attitude better. It seemed like it controlled to a rate deadband that was smaller than the RCS deadband. I don't know why you're using the same gyros and the same electronics. The only thing that could be different would be the attitude drivers on the RCS might be activiting slower than they are in the OAMS. It seemed like the rates were such a--seems like there must be a lag in the whole system. It seemed like the deadband in the RCS was twice what it was in the OAMS. It operated properly. There's so much difference between looking at that ball on firing retros and looking out and actually seeing the nose of the spacecraft moving around out there. There's no comparison with the simulator. You just can't simulate this. When I looked down at the ball and did the retrofire, it was just like the simulator. When I was looking outside and actually seeing what the spacecraft was doing as I controlled it, it seemed like it was a lot sloppier with the RCS than it was with the OAMS.

White We must have fired over New Mexico or Texas.

McDivitt Our retrofire?

White Yes. I could see the old brown sandy earth down right under us.

McDivitt Yes, Guaymas gave us our countdown, so we were over northern Mexico.

White That's the area that I thought we were over. Actually, it may even look almost a little like west Texas.

McDivitt It could have been. Then I did T_R-5. I went to our retro attitude. We reported our T_R-5 checklist complete. I don't know exactly when Guaymas came on the radio.

5.6 T_R-1 Events

McDivitt Yes. At T_R-1 there wasn't really much that we could do in advance, but whatever we could do, we did. There weren't many steps.

White We just waited for -1 minute.

McDivitt All you have to do is really just prepare yourself mentally, but at T_R-1 I told Ed, "We're at a minute," and I guess Ed already knew we were at a minute.

White Yes.

McDivitt Ed did it just exactly as we'd briefed it many times. You punched the SEP OAMS. We heard the bang. He followed with a SEP ELECTRIC, rather quickly afterward as we had planned. We heard the bang. Then we waited a short time as we had planned, and fired the SEP ADAPTER. Then there was a great big bang. The tendancy is to punch those buttons 1, 2, 3. We decided that we didn't want to go 1, 2, 3. We wanted to go 1, 2, (pause) 3. That was exactly what we did, and there wasn't any doubt whether the equipment adapter separated.

White I had no inclination to look around. I knew it was gone.

McDivitt That's when Ed hollered, "There go the pump packages! I see two pump packages out there. Just exactly what John Young said!"

White They separate right off to the left side. Jim couldn't see them because of the position of his head. I could see them.

McDivitt That's right. I never saw them at all.

White I could clearly see the two pumps together on the mounting and mounted together. They were right together. And I'll back John up to the hilt on that one. I saw them too.

McDivitt We got the adapter separated with all the attendant flying pump packages.

White Quite a flourish, isn't it?

McDivitt Right. It sure is. It was a big bang. There's no doubt about it. At T_R-30, the T_R-30 sequence lights came on, and at that time Ed said, "The sequence lights came on about a second or a second and a half in advance." So, I armed retro squibs, and we discussed whether or not to punch off the auto-retro button or not. If the TRS was fast, I didn't want to punch it off ahead and have the retrorockets go off early, but I figured that it wasn't in a hurry that much. But if it came on much earlier than that, it was really going to make us short. So, I finally decided that we'd go ahead and arm the auto-retro button at about 3 seconds so that we weren't going to be any more than 15 or 20 miles short as a result of the retrorockets going off early. We'd still get the auto-retrofire signal through, so that if something went wrong with the manual retrofire signal, we'd still get the retrorockets fired. I felt that 3 seconds early would be better than a possible 15 or 20 second one in case we had to go through some non-nominal method of firing the retros in case the manual button didn't make it work. I told Ed to arm the auto-retrofire, and he did this at about 3 seconds, and it fired automatically at between 2 and 1 seconds, I think, in the count.

White Yes.

McDivitt I felt that we got a one-plus second early auto-retrofire.

White Right. I did too. We went through the little discussion there from -30 down, and I knew what Jim's point was. I think I distrusted the system a tad more than Jim did, but I thought his logic was good. We had two systems working to fire the rockets. I was in full agreement.

McDivitt We went through and saved fuel for 4 days so we could do an OAMS retrofire. I felt if we're going to adopt that sort of philosophy and go through that long of a lean fuel period, then we could afford another few miles of inaccuracy thrown in by an early retrofire if we got the redundancy that you would get from a double-firing. So, I elected to go ahead and have Ed push it. Although it probably contributed on the order of 8 to 10 miles to our miss distance, I don't think it really hurt us that bad.

5.7 T_R-0 Events

McDivitt I had the spacecraft in the retrofire attitude, and when the retrorockets fired, I--

White I had also pushed the manual button on time. So, it was about a second after they actually fired.

McDivitt Excellent. The spacecraft was in the proper retro-attitude and we got a real good push from the retrorockets. There are four distinct pushes, and I never felt a pause between any one of them. Did you?

White Yes, a little pause between each one. I think my cues were tuned up in a different manner than yours. Yours were working on the controls. Did you feel that you could actually see the acceleration? You weren't looking out the window.

McDivitt I was a little bit. It looked like we were actually turned around and started back the other way. Ha, ha!

White I really could feel the g's. Nothing that was uncomfortable, but I felt each one of them, and I also felt looking out that I could see the spacecraft slowing down. I know it was such a piddling amount compared to our velocity, but I was looking down on the ground when they fired. Your view of the ground is considerable at -30°, and it did seem like I could see the spacecraft actually slow down.

McDivitt I don't know what the magnitude of the g's was during retrofire. We were super-sensitive, I'll tell you that. We'll get to that later. As a matter of fact, later on when I was debating about whether or not the g-meter worked, I stopped and hit the reset button, and it did come down. It came down from something less than one to zero.

White I'd say between $\frac{2}{10}$g and $\frac{1}{2}$g during retrofire.

McDivitt I'd guess something about that order too. It sure seems a lot.

White Your cues are really up for the g's.

McDivitt You've been at zero-g for so long, anything feels like it's a lot.

McDivitt I was at zero rates and in the proper attitude. I was in rate command when the retrorockets fired. I maintained the attitude very well. It was very easy. There were no deviations at all. Ed was standing by on the roll rate gyro in case it looked like I was losing control in yaw. He could turn off the roll rate gyro and get all the authority that I needed in yaw. As far as I could see, it never deviated more than a degree from where I was supposed to be. I don't think it ever got off that center bar in yaw, and it never got a dot--that little dot--away from the 30° mark as far as I could tell. Could you see any, Ed?

White I was sitting there watching it and enjoying it at that time, because the attitude was staying right on.

McDivitt Yes. It was right on. We got the ΔV in the right direction. Now, the IVI's didn't read out, because we didn't have the computer on, so we really couldn't tell.

White It was as steady as a rock. You could see the decelerations and, looking out the window, I couldn't detect any movement in attitude. I was looking right down on the ground several times during several of the retros, and I think you could detect motion fairly well. I didn't see any.

McDivitt I'll tell you. I was really happy after that OAMS retrofire and the retrorocket retrofire. I figured that we had exactly what we were supposed to, and I was positive we were going to come down on that cotton-picking carrier. I was really quite happy after that, because I don't think even in the simulator we ever had one that easy.

White Shall we make our admission on OAMS retro at this time, Jim?

McDivitt Yes. As a matter of fact, it might be appropriate. I'm probably one of the biggest antagonists to the OAMS retro-

fire that there possibly is at the Manned Spacecraft Center, because I think it's a fuel-wasting maneuver and a lot of other things. I still think it is. I'll still say one thing--after I fired the OAMS retrofire and I knew I was going to come down, I was a lot more relaxed than I had been before I got there. I'm going to have to tell Dr. Gilruth that, but I still think we can get by without it.

White — It was nice to see it work. It was nice.

McDivitt — It was, and I was real sorry we didn't have a computer because after those two things, which I thought were done certainly as good as I could possibly do them, I felt sure that we could have landed right on the cotton-picking carrier's deck, if we just had a computer to tell us where to go. I would have liked to have tried the guidance. I worked hard enough on that reentry guidance and I didn't get to use it.

White — Jim, I think there is one thing that we left out--the reading of the percentage of OAMS fuel left. I think we called out 3 or 4 percent.

McDivitt — That's right. I had 3 or 4 percent remaining on the gage. We called it out and it will be on the tape.

White — I wrote it down at 3 percent. Here it is. Three percent of the fuel left after OAMS.

McDivitt — Yes, and it was a little hard to read down there and parallax was pretty bad. I estimated that it was 3 percent.

White — I read off the quantity on the gage, and it was a little over 1100.

McDivitt — 1100 psi?

White — Yes.

McDivitt — I'll tell you one thing about the out-the-window view at 30° pitch-down attitude. You're really pitched down at 30°.

White — That's another thing that I noticed. I was looking out the window, and I surely wasn't observing much in the way of a horizon. I was looking at the ground.

McDivitt — The top 2 inches of the window has the horizon in it. So if you really had a bad retro and you got screwed up a little bit, you could lose your horizon.

White You could lose your horizon, but I think you've got a good enough view of the motion of the ground and an object on the ground. I think you could do a very effective job.

McDivitt If I really had to do an out-the-window retro I'm not even sure that I'd look out and use the horizon. I think I'd pick a spot on the ground.

White That's the point I was making. You'd put a grease pencil on your window.

McDivitt You'd have to use both.

White I think you'd find a spot on the ground, and hold it.

McDivitt Because the spot on the ground is going to move.

White Yes, it's going to move during the fire. That's exactly what you do on an attitude ball, you know. You have a horizon and you have a spot and then you fly that spot. So, it sounds kind of like the thing I think you can do.

McDivitt The retrorockets fired, as I said, in the order 1, 2, 3, 4. We got the manual fire out--button punched. I'd got that. We had said that because we're getting a countdown, we were going to fire the manual retrofire button exactly when we got to zero. We weren't going to wait around a second after that, so that we got the computer and all that jazz on the line. We didn't have any computer to get on the line. We weren't going to read out anything on the IVI's or anything else. All we were concerned with was firing the retrorockets.

5.8 Retropack Jettison

McDivitt I waited 45 seconds. I started rolling over at this time. When 45 seconds came, I had the retrojett squib on, and I punched off the retro--

White The light came on and you punched it.

McDivitt That's right. The light came on at 45 seconds, and I punched it. There was a real solid bang, and I knew we separated from the retropack. No doubt there either. As we went on down, we finally saw the retropack come on around behind us.

McDivitt Do you have anything else on the retropack jettison? I guess not. That's pretty simple.

5.9 Communications

McDivitt We got the com from the ground.

White I thought we had good communications with the ground.

McDivitt No problems with the communications. I was a little concerned with the communications earlier in the flight, because we weren't getting anything. We weren't getting retrofire times or any other information. But towards the end of the flight, communications were excellent.

5.10 Update

McDivitt The update was awful, I think. As I mentioned earlier, they updated our TRS, but the TRS was obviously not running with the ground.

6.0 REENTRY

6.1 Reentry Parameter Update

McDivitt We really didn't have a reentry parameters update postretro. We went into blackout pretty quick. There wasn't anything to update. We were going to start rolling at 400 000. Regardless of anything else, we had a preprogramed reentry.

6.2 400K

White We were at 400K before you got your 3-minute update.

McDivitt That's right. At 2 minutes 38 seconds we were through 400 000 feet. We got there in a hurry. I rolled upside down, and I flew down to 400 000 feet, which was to be at 2:38. However, I thought that we'd retrofired a little early, so I wasn't in any great rush to start my rolling reentry. I delayed about another 30 or 40 seconds. The only reason I delayed was because I knew there wasn't any rush to get over, because if we were going to be any place, we were going to be short. I just wanted to get over and get in a good attitude. So, I rolled the thing upside down, got the--

White One thing--on the postretro checklist, we decided this time to use reentry rate command rather than direct.

McDivitt That's right.

White That's a deviation on our checklist.

McDivitt When I got the thing upside down, I was still in rate command. I held the lift vector up, heads down, until I got down to about 3 minutes and 15 seconds. I got my 3 minute time hack from the ground. I got my clock counting up at 3 minutes. At about 3 minutes and 15 seconds I started the roll. What I did was, I put in about 15 deg/sec, and then we turned off the roll gyro. I just left the thing rolling. I controlled the pitch and yaw inside the rate deadband, which was ± 4°, just as you would in direct. I still had the the rate deadband to take care of any wild perturbations that we got into.

6.3 .04g

White We didn't even have a time for .04g, did we?

McDivitt No. We didn't have anything like that. We started rolling reentry at 400 000 feet, except that I didn't start it until about 45 seconds after that to make sure that I had good attitude. I started the thing around the way I wanted it. Just about this time, we saw the retro adapter start floating back past us. I figured the other day that thing was small-end-forward rather than blunt-end-forward.

White I'd say it was front-end-forward too.

McDivitt We saw the spherical end of the retrorockets. Remember?

White Yes. All four of them.

McDivitt All four of them. We didn't see the nozzle. It had done a 180° turn small-end-forward and it was as stable as a rock. We could see the whip antennas sticking out to the side.

White Exactly the position it should go to. That's the heaviest end, I would presume.

McDivitt It would tend to trim that way too. Except that I didn't think there would be any aerodynamics at 400 000 feet. But it was turned around 180° and was perfectly stable with the whip antenna sticking out, which at that time was up to the right.

White Yes.

McDivitt We were upside down. It sure was a funny looking sight.

White It sure was. It was really pretty.

McDivitt And it was as stable as a rock and very slowly drifting behind us. As a matter of fact, for a while I thought that our opening velocities were too slow, and I thought it would just come back and hit us. But, it just stayed out there, and we started our rolling reentry there. We were coming on down and we were rolling around and before I got any noticeable g's at all--isn't that right--before we got any noticeable g's, it started burning?

White Okay. We saw the reddish-pink layer coming around the spacecraft--

McDivitt Well, didn't we see the retropack start burning before the--

White Whichever way we saw it, it's on the tapes, because we discussed it pretty thoroughly.

McDivitt That's right, as we were doing it. But I sort of vaguely recall that watching the retros after us as we spun around, it started glowing a little bit, and then you could see this big spray come off the front--shock or something. It looked like it was just melting and coming away. It just looked like a great big orange mushroom back there, and that's when it really started falling behind us.

McDivitt We hadn't felt any g's at all. Had you felt any g's?

White Not that time.

McDivitt I'm sure that I hadn't felt any g's.

White I was wondering why we were so light. We were looking down at Florida. We had watched Florida go by and commented on it.

McDivitt Shoot, we really made a low altitude pass across the States. We should have probably filed a DD-175 to get clearance.

White We had to come through the control zone, you know, at Eglin. They're kind of sensitive about lower altitudes.

McDivitt ... started glowing and burning and it was as stable as a rock as long as I could see it. Did you ever see it tumble?.

White No, never did.

McDivitt Okay. It was behind us and it looked like it just ate the front right off, and I guess when we first saw it, it was on the order of 200 feet, maybe?

White Yes.

McDivitt And the last time I saw it, it looked like it was about $\frac{3}{4}$ ....

White That was about the position that I saw the booster for the first time.

McDivitt I think you're right. I guess we could see the dome on it and all that stuff. As a matter of fact, it was a pretty good reentry shape. It looked stable as a rock.

White It stabilized right out.

McDivitt So, we finally saw it drop behind us and burn up. As it finally started drawing behind us.

White We started to get --

McDivitt The first thing I saw was the orange flame--the orange or pinkish flames coming out. It looked like the flame was coming up around my side of the spacecraft like this. Was it doing that on your side, too?

White Yes. It looked like it was almost coming from three points.

McDivitt Okay. Probably what it was doing was coming around both sides because of the angle of attack and going out this way. But I definitely could see the orange fire come up around the left-hand side of the spacecraft and out in front of the window, and pretty soon I saw some green fire--

White Coming out of the top --

McDivitt Oh, is that where you saw it? I didn't. I saw the green fire down close to the left-hand side coming up over the nose inside of the red fire, and then it was all swirling around there. Then while we were coming down, we were coming down in a roll, but with our relatively high L/D, we were in a great big roll with a big wallow. I guess this is really indicative of how much lift we had.

White It looked to me like we were getting a lot of lift out of it.

McDivitt It looked to me we were getting an awful lot of lift out of it.

White It was really whipping around there.

McDivitt And we were going around at a pretty good rate. The needle was off to the left. That's right. It moved out slowly, slowly and got out to about 2° and it just held there. The spacecraft was as stable as a rock. I damped the thing a couple of times in pitch and yaw and it just stabilized right on down there. I don't think I even touched the pitch again.

I think I maybe touched the pitch four times all the way down and the yaw maybe six or seven times. What I was looking at was just a huge portion of the sky. I could see the ground, then I could see the sky, and I really saw a lot of the country as we came rolling by.

White That thing was a real lifting body. You're really getting a lot of lift initially, and if you roll around there, you'd kill it all off; and your aerodynamics is such that you really can't tell, because the stability is so loose right there. You know you're going to get some lift if you have an offset CG, but you couldn't tell where it was going.

McDivitt You're in the area where you're getting a lot of lift so if you do a roll, you've lost that range right off the bat. We came down on this great big spiral, and here I think we ought to get into--

6.4 Acceleration Profile

McDivitt -- the acceleration at retrofire. I called down on the ground and told them that we had four retros. We got automatic. We got autoretro. We got all four in sequence. We got autoretro. Autoretrofire appeared to be about a second and a half early. In the acceleration profile I said, "Well, here come the g's, Ed," and I felt the g's going up. He said, "Yes."

White I said, "Yes. There are two of them, aren't there?"

McDivitt Yes, and then we waited a while longer and--

White I said, "Gee, there's nothing on the g-meter."

McDivitt I said, "The g-meter must be broken," so that's why I reached up and reset it. It actually went down a little bit. So we went a little while longer, and I said, "Ed, I feel a lot of g's," and he said, "So do I." Then he said, "We must be up between three and four."

White It felt like that.

McDivitt And I said, "Yes, I think we're up about that high too." And the g-meter was still reading zero for all practical purposes. Pretty soon it started building up slowly. It went up to 2, 3, 4, and I called out at 2, and I called out at 4, and I called out at 6, and I think I called out at 7.

White — About the time you called out the 2, I knew we had been had.

McDivitt — Yes. It's just that we were super-sensitive to g's, and the load pulling us into the seat was on the order of a tenth of a g.

White — It's true.

McDivitt — So we had 0.1g and we thought we had 3. And we both felt this way. The g's went up to about $7\frac{1}{2}$. They told us we would probably get 8g coming down. When we got the instrument positions back from the spacecraft, the postlanding switch positions, they had the g-meter marked at $7\frac{1}{2}$g, and I suspect that's probably about as high as it went. Now, I'm telling you this was really a piece of cake. I thought that maybe $7\frac{1}{2}$g after being out there for so long would be tough, but I didn't even have to breathe hard to get any air. I just lay there and relaxed and enjoyed the whole thing, and I really got a big kick out of that reentry.

White — We chatted back and forth. We talked through the whole g-load, and I was watching outside and inside. I was looking out quite a bit of the time when things were going so smoothly, particularly the g-load. When you get to the high g's, you might as well look out, because you're not going to do anything about it, and I noticed no dimming in vision. Everything was as clear as a bell. Not a speck. I could see everything on the instrument panel, and I could see things very clearly outside.

McDivitt — Things were going so smoothly on the inside that I looked out too. I enjoyed the scenery on the way down.

White — Once you get in that position and you get the high g's you're not going to do anything inside.

McDivitt — In the amplitude of the oscillations, all the simulations show that they tend to decrease as you get to high g's and the frequency picks up. So the only thing you could do is hurt things if you start screwing around with it, except we didn't have any oscillations anyway. It was just as stable as a rock.

White I think at this point I'd like to put something in. I'd like to find out when they analyze the data whether the upper right-firing thrusters on my side were firing a whole magnitude more than the right-hand upward-firing thrusters. In fact, they very early in the profile became a cherry red and just stayed red hot, even a little bit white hot all the way down.

White There was no frequency to it at all. It appeared to me they were firing continually, and I think maybe this might associate itself in some way with something in the system prior.

McDivitt I think it was prior, because we were in reentry rate command and we started the roll. Then the yaw needle drifted on out, and it looked to me like it never got over about 3 deg/sec. I was trying to read the 0.1 deg/sec scale. It might have gone on to 4 deg/sec with the roll rate we had in there, and the jets just kept right on firing constantly.

What I had done when we started was to leave the roll gyro on, and I rolled the thing over till I got almost full deflection on the needle. Then I put the roll gyro off so I'd have 15° and we wouldn't tend to overrate the thing so that the reentry rate command was firing all the time. What I think happened was that as we went on down, the yaw rate needle tended to drift on out. I don't know if you noticed it or not, but it tended to drift out. It started at around 2 deg/sec, and it drifted on out slowly until it got to about 4°. I thought it never got out to more than 3 deg/sec. Later on, when we started oscillating around like we did, if the thing were out at 3° and started banging back and forth at all, the yaw thrusters would be on constantly; and also that's the side that they'd be on. It would have been on the right-hand side. Are you sure that it was red that high up, or did it get red when we started getting down where we got all those oscillations? Because there I'm sure it was firing all the time.

White It was red for a long time, Jim.

McDivitt Was it?

White I was actually watching it, waiting for one of them to bust loose, because it was really firing a lot more than I thought it was out there. Jim asked me about the frequency of it, and I couldn't tell whether it was on or off. It was red all the time. The other one was hardly heated up at all.

McDivitt Shoot. There wasn't any need for any kind of firing then.

White It would be interesting to see if the other yaw thrusters were.

McDivitt Well, it'll be interesting when they cut these things apart to see what kind of life cycle--

White It really had a good workout.

6.5 Spacecraft Control

McDivitt Spacecraft control was like a dream. A good engineering description. There weren't any oscillations. It was as stable as a rock. I don't think we need to say much more about that. It wasn't like any failure simulation we've seen. It was the easiest thing to control, easier than any simulation I've seen. Shoot! A baby could have done it.

McDivitt We started getting oscillations around then, and the reentry rate command fired a few times, and I damped it in pitch and yaw. There really wasn't any control problem to it at all, I didn't feel. Did you think there was?

White No. I would have been watching closer if I had thought there was.

6.6 100 000 Feet

McDivitt The altimeter was at 96 700 feet throughout the entire flight. It started on down, and we were still at about 5 or 6g when that thing started on down. It went on down to about 92 000 feet, and then the g's started off, and the altimeter started back up again. It went all the way back to about 96 000 feet again, and then it started down again. The second time it started down, it really started down in a hurry, and I was sure that we were still at 100 000 feet.

McDivitt So, I waited until the g level got about 3, which is around 80 000 or 90 000 feet. I started slowing the roll rate there. I wanted to get the thing to a zero roll rate by the time we got to 40 000 or 50 000 feet, certainly by the time we got to 40 000. We started gyrating around some more, but I didn't think it was exceptional. The reentry rate command started firing. As a matter of fact, I said, "Here

comes the reentry rate command," and then I was firing on top of it so that we really weren't oscillating too much. Then we get to 40 000 feet, and I put the drogue chute out, and that's where things really got exciting.

6.7 50 000 Feet

McDivitt I put the drogue out at 40 000 feet. We were nice and stable as we went down. We were a heck of a lot more stable than we were when we put the drogue chute out.

White That's right by several orders of magnitude.

McDivitt When we put the drogue chute out, we were concerned about the thing destabilizing rather than stabilizing. So I intended to put the drogue out and leave the control at reentry rate command. This I did, and we oscillated all over the sky. We estimated ± 40°, and I think we were at least every bit of that.

White We were, and when the drogue chute came out, I was right in the sun so I couldn't see it, and I didn't know whether we had one or not. You called it out, and about the time you called it out, I could see it up there gyrating wildly around.

McDivitt I never could tell whether the thing deployed or not. I had a lot of goop on my window, and the sun was out, and all I could see was the shape of the drogue up there, and it really was fluttering around. We were ± 40° to it without any doubt, and I wouldn't be a bit surprised if we weren't ± 60° to it. We were really getting tossed around. It was just jerking all around.

White It was fast, but I don't think it was that big a magnitude. (McDivitt is making a noise to describe it.)

McDivitt About like that.

White I was really surprised the thing held on there, to tell you the truth.

McDivitt So was I. I was expecting the drogue chute to fall off any minute.

White I was, too.

White It worked all right.

McDivitt It held us together.

White If I went through it again, I'd be perfectly happy sitting there riding through it, to tell you the truth.

White The way I looked at it, it was rather interesting. I hadn't quite expected that.

McDivitt Neither did I. I know that Gus said that he had a pretty wild ride, and he thought the thing was destabilizing him. He had a scheme where he just turned off the propellant valves to stop the propellant flow. That meant that he had to wait about 10 or 15 seconds to get the propellant valves back open again to get the jets firing. Well, I wasn't going to do that. I thought the thing to do was to turn off the electronics and see if the thing was going to become unstable. This is what I did. I turned off the RCS electronics. The thing was that they didn't get any worse. It didn't get any worse. I watched it. I could see enough of it to tell that we weren't becoming unstable.

White It was unstable to a point, and then it stabilized out in this oscillation.

McDivitt That's right. It was really gyrating around. By that time we were down to 20 000 feet, and I called, "20 000 feet. Pull down the handles," or something to that effect.

White You called out 28.

McDivitt Is that what I said? And then, I pulled the propellant valves, as I had planned to do, and turned the control mode to rate command rather than reentry, because I wanted to burn up all the fuel that I could out of those manifolds. As a matter of fact, I was interested in burning up all the fuel I could before I got to the ground.

White I have a question. I thought you put it in rate command before you turned off the valves, and it pretty well damped itself out on the drogue.

McDivitt No, I don't think I did.

White Okay.

McDivitt I don't think I did. I think I left it in reentry rate command until I turned it off and then turned off the power.

I went from ACME to OFF on both rings. It didn't get any worse. I think what I might have done is I might have gone from OFF to ACME to rate command, to turn the propellant valves off rather than going from--

White Well, I know it damped out there in the end considerably. I think it was when the rate command, or whatever it was, was firing.

McDivitt Well, reentry rate command was going all the time. We were going at a heck of a lot faster rate than 4 deg/sec.

White Well, we cut down our oscillations considerably after you did something over there. I thought you had put it in rate command.

McDivitt I did put it in rate command, but I didn't leave the propellant on. This was why I wanted to get rid of all the propellant onboard the spacecraft if I could. But I didn't want to let those things fire for a long time and maybe eat up the drogue chute, and find ourselves without propellant and without drogue chute, too. So, once we got the drogue chute out, I let the things fire for a while and turned the electronics off. Maybe I turned it back on and went to rate command, and off with the propellant valves. I'm not really sure.

White I think you had it in rate command for a little while--probably while you were firing out the fuel.

McDivitt Yes, that's what I did. I went to rate command and let all the fuel fire out, just as we had planned. So that I was sure that the rates were high enough that we were going to fire out the fuel without distrubing the thing on the drogue. So we fell on down. Ed got the snorkel on the vent valve about 28 to 27 000 feet. We came on down. I watched the altimeter go through 11 000.

6.8 Main Chute Deployment

McDivitt At 10 600 I punched out the main chute. I saw it go out with a lot of crap and corruption flying off the nose. It went out and came out in a reefed condition, and I saw and I said we had a good reefed chute. I don't guess you could see that too well, could you?

White No, I couldn't see the chute out. I saw it finally when it deployed.

McDivitt I saw the thing hanging up there just the way it was supposed to, and then the thing dereefed, came billowing out just the way it should, and I said, "We've got a good chute." One edge of it collapsed and came back in and collapsed about a third of the chute. We've seen a lot of movies of these chutes coming out, so I wasn't really worried about the thing collapsing. It went in and came back out.

6.9 Communications

McDivitt There weren't any communications that I could tell, were there? Maybe we received some transmissions on the drogue, but I'm not really sure. As soon as we deployed the main chute the antenna came off. So we couldn't talk to anybody after that.

White I don't think we got anything on the drogue.

McDivitt I'm not really sure that we did.

White I don't think we did.

McDivitt Shoot! We were getting thrown around so that we couldn't have heard anything anyway. They tried to communicate with us a couple of times after we came out of the blackout and before we put the drogue out. I didn't hear exactly what he was saying. He wasn't hearing anything I was saying either as far as I could tell. He wasn't acting like he heard what I was saying.

White He gave us our blackout times of 5+23 and 9+21, and there really wasn't too much we could do to check these out.

McDivitt After we got the main chute deployed, I told Ed, "Quick! Take your blood pressure." The chute came out around 7500 feet or so, and when we finally got the thing dereefed we were floating down nice and gently. Ed started taking the blood pressure, and it seemed like it took an eternally long time. By the time we got down around 5300 feet or so, I said, "Ed, get the blood pressure done because at 5000 feet we're going to go to a two-point attitude." He fooled around and fooled around and fooled around. Finally we got down to 5000 feet and I said, "Ed, you've got about 3 or 4 more seconds, and we're going to two-point attitude."

White It was a little slow. I don't know why.

McDivitt I didn't want to trust that altimeter. Ed kept fooling around with that blood pressure without getting any air out of it, and finally I said, "Okay, Ed, we're going to go to two-point." I guess by then he had the blood pressure completed.

White I think we got a good blood pressure.

McDivitt So, just like we'd always practiced, I said, "3, 2, 1, MARK," and punched the single-point release.

6.10 Single-Point Release

White We both had our heads braced up on our arms.

McDivitt We had our arms up on the windshield and my head wasn't exactly on my arm. Was yours?

White My head was on the arm and pressed over to the side of the spacecraft. I was well wedged in, I felt.

McDivitt So was I. My head went forward a little bit, back a little bit, then back up forward again, and it didn't hit anyplace. Did yours?

White No. I had my head pressed on my arm the whole time. I don't believe it left the arm very much, because I actually had it wedged from behind, too.

McDivitt So, I thought going to two-point was a lot less violent than the ride on the drogue.

White I agree with you. I think we've got a good operational procedure of bracing your head on your arm up against the window--a satisfactory procedure for this.

6.11 Postmain Checklist Items

White We took the blood pressure on the main chute, too. I went through what I called the reinforcement items on the checklist that I wanted to get off right away, and then I sat back and pumped off another blood pressure. About this time you were making your calls to the recovery force.

McDivitt Right. I started calling the recovery forces as Ed was taking his blood pressure. We got some response from Omnibus right away.

White Good old Omnibus.

McDivitt Yes. And we went right on down. We stowed the D-ring covers. We stowed the D-ring covers between deploying the main chute and going to two-point, just as we had planned. We didn't want the D-ring to flop around there, and once you go to two-point, it's too late to eject anyway.

White I called Jim to unstow his D-ring at 35 000 feet and he took his out at that time. I pulled his right arm lift up, and I saw him pull his left one up.

McDivitt No, I didn't get my left one up. I made three passes, and I said to heck with it.

White I thought you got it. I struggled with mine and finally got it up. I had both of mine up, and you went on and completed the checklist.

McDivitt I knew Ed wanted me to get my D-ring out because I was the guy that was going to have to bail us out.

White Again I'd come down with this big bag of stuff resting on my legs up against the bottom of the seat, and as we approached 35 000 feet, I pulled this up in my lap, and just held it. We had agreed that Jim would do the ejection if we had to, and I would just take the ride. I didn't unstow my D-ring. I just sat there. That's why I made pretty sure that Jim got his out.

McDivitt After we got on the main, we went through and turned off all the switches, just as we were planning on doing it. I turned off all the switches on the middle circuit breaker panel except the ones on the last couple of rows. I turned off the IMU, the rate gyros, the horizon scanner, and those switches on the center pedestal. I didn't turn off any over on the left hand side except the landing attitude circuit breaker.

White May I ask you a question? Did you think it was a shorter time from 7500 feet down to the ground than it was in the simulator?

McDivitt Yes, as a matter of fact I did.

White I thought it was a considerably shorter period of time.

McDivitt Yes, we went from 5000 feet to the ground in nothing flat.

White You're not kidding--nothing like we go down in that simulator. I would be curious if we had any data that tells us what our descent indicator was telling us on our descent?

McDivitt It was jumping around. It was between 30 and 40 ft/sec like it does in the simulator.

White It seemed like we went down awfully fast. I would have already finished turning off everything in the simulator with quite a bit of margin, but, of course, I did take the two blood pressures in here. I got all the essential switches off and started turning off nonessential ones when you called out a thousand feet.

McDivitt At a thousand feet I said to get ready to pull out the water seal.

White That's right.

McDivitt You got the water seal out at about 700 feet?

White I pulled it about 500 feet.

McDivitt We pulled it lower than we usually do because usually we're sitting there waiting to go through a thousand feet.

White Right.

McDivitt We got down to about 300 feet, and I said let's prepare for landing.

White Right.

7.0 LANDING AND RECOVERY

7.1 Impact

McDivitt We got down to about 300 feet, and I said, "I guess we ought to get ready for landing." But as John Young says, "How will you get ready for landing this thing?" So as he did, we just sat there, and we went through zero feet, I believe, on the altimeter.

White We hit very close to the water with zero on the altimeter.

McDivitt I think we hit at about -100 feet or so. Anyway, we really plunked down in the water. We hit ten times harder than I expected to hit. The altimeter was set at the lift-off setting. I didn't fool around with setting it.

White That's an interesting point. They ought to give you an altimeter setting for the landing area.

McDivitt I don't think that would do any good. I wouldn't trust that altimeter within a thousand feet.

White No, but I'd rather have my reading on it that much more accurate. You've got a ship sitting out there that could give you the exact altimeter setting. Here we had an altimeter that we hadn't set for 4 days. I hadn't thought about this.

McDivitt The last time that altimeter does me any good is when I go through 10 600. Well, I guess I use it down to about 5000 or 6000 when I'm trying to get the two-point suspension. It's useful there, too.

White It was a good indication that we were coming up to 1000 feet and to get ready for landing, Jim.

McDivitt Yes. Like I said earlier, how do you get ready for landing? All we did was sit there.

White We've got to stop throwing switches.

McDivitt Yes, I guess so.

White I think it would be a good procedure to go ahead and get an altimeter setting.

McDivitt I suppose it would. It only takes you a second to crank the thing in.

White Yes. It's there. We ought to use it.

McDivitt Well, we hit the water with a real wallop. Then I sort of felt that we went into about a 150° roll to the left and were dragged backward. We were almost upside-down going through the water backwards. Now, the CAG here saw us hit. He saw us from about 100 feet on down. He said it looked like to him, that we came down and hit the water and tilted the thing up over the top. He said we were going blunt-end-forward, but we were actually tilted over the top. We then did a pitch-down maneuver about 180° in the water. I was surprised that we were being dragged backwards, but I got the sensation that I was going backwards and almost upside-down.

White I had the kind of feeling that we went in and touched over a little bit, and that's about all the feeling that I got. I don't believe we got dragged very much.

McDivitt No, but I just felt that was the way that I was going. I was being pressed back in my seat like I would be if I were being dragged, and I was thrown over to the left like I would have if we had rolled over this way.

White I got the left roll and I also think that I had less water in my window than you did. I had a lot of spray and stuff. Did you have solid water in your window?

McDivitt I really didn't look that closely. I didn't look at the window to see what I saw there. I saw nothing but water sloshing all over the thing. We really seemed to hit hard, harder than I thought we would, but it really wasn't too hard.

White To put everything in a comparison, the ride on the retro was more than I expected, the drop to a two-point suspension was less than I expected, and the impact was not as much as I had experienced on the drogue, but more than I had expected. In other words, the biggest surprises I had in order of magnitude were the ride on the drogue, the impact, and I didn't think that I had much surprise at all in the two-point. I was expecting a big jolt and got not as much as I had expected.

7.2 Checklists

McDivitt — We'd gone over the normal water egress checklist in flight before we came down. We did this in that 3-hour period while we were preparing for retrofire. I read it over to Ed while he was stowing things, and we went over it in detail again as to what we would do. Also we went over the emergency egress in case we had to do that. So we had it fresh in our minds.

White — We turned everything off that wasn't needed after landing.

McDivitt — Ed had the postlanding checklist and he read it out to me--the things that I had to do. The only thing that I didn't do was to take my helmet off and stow it. I did get my arm restraints down. I didn't put my drogue mortar pins in until I was getting out, and I never did put my seat pin in. It doesn't say on the checklist to put it in.

White — I put your seat pin in.

McDivitt — Ed put my seat pin in for me. Now, we'd got all the switches in the right positions, I think, except one. I forgot to put my FDI to the OFF position.

White — I think all other switches were all right. All our pyrotechnics were safed.

7.3 Communications

McDivitt — I talked on UHF. I talked with Omnibus, and I finally was talking to Inkspot 6., the helicopter. I talked to him and I heard him, and we established excellent UHF communications. I heard Gus coming through the auto cap two times, I think--very weak, almost unintelligible. I think he was asking how we were, or if they had us yet. I kept making transmissions in the blind to him. I don't think he was ever getting any of them. Ed operated the HF, and what do you have to say about that?

White — Okay. I put the antenna out and turned the HF on. I went through one call, and then I went through a short count on the HF. I heard nothing and received nothing from anybody else. This was about 5 minutes or so after we had been on the water that we actually made the HF check. Maybe it wasn't over that long. As soon as I got all the switches where I wanted them, I went ahead and--

McDivitt I saw you put the antennas up, and you went ahead and put in a transmission pretty quick.

White Right. I didn't make another check on the HF. I hadn't been too impressed with the operation of the HF up to this time, and things were getting pretty busy. Five or 10 minutes later we had the recovery people on. I guess we're going to get to that. I heard them say we had a helicopter almost overhead.

McDivitt They called just after we retrofired, I think, and before we got to blackout--called and said that they should have a helicopter over us in 5 minutes. We didn't get any onboard data. The ground information that I got was, as I said, from Gus. Then right after we hit, Omnibus said, "I got them in sight. I'm 48 miles out on TACAN radial .," something or other. So I figured we were 48 miles from the ship. Well, anyway, I was pretty sure we were 48 miles from the ship. Then I heard them calling back and forth saying the helicopters were only 15 or 20 miles away, and they were there in just about nothing flat. We had a good status report on where everybody was. They were on our frequency, and I could hear them dumping their swimmers into the water and standing by and throwing smoke bombs out and seeing the dye markers; and we had more activity than the fourth of July.

7.4 Systems Configuration

McDivitt Okay, as we hit the water, Ed closed the inlet snorkel to make sure we didn't get any fumes in as I punched the parachute jettison. Shortly after that when we decided for sure that we wouldn't see any fumes--we sort of talked about it a little bit, and I peeked out and I guess you peeked out. Didn't see anything but steam coming out of the thrusters and then saw the dye marker out there--I reached up and reopened the inlet snorkel.

White That's right.

McDivitt I put the recirc valve at 45°.

White Actually, shortly after we got on the water, I noticed the acrid smell that we were to have for the rest of the time we were out in the water. On the ECS system I could actually feel the relief that the pumps and the snorkel (open positiion) were giving us. It did provide some flow. I really didn't think that the heat was oppressively hot, to tell the truth.

McDivitt No, neither did I.

White It was uncomfortably warm--I'll put it that way--and very stuffy, but I wouldn't say it was over-bearingly hot. It wasn't as hot as I thought it was going to be in the spacecraft.

McDivitt I thought the worst thing about the whole thing was the smell. Whatever was burning later was the heat sheild, I guess, because I went out and smelled the spacecraft later on when I was onboard the carrier, and it smelled the same way. This terribly nauseating acrid smell was still all over the spacecraft, and it seemed to be worse at the heat shield. So I assume that's what we were smelling inside.

White How was the control, Jim?

McDivitt Spacecraft control in the water is lousy! I couldn't take out the motions. The rates were terrible, uncontrollable! Why don't you discuss the electrical. It was over on your side there, Ed.

White Well, there wasn't really much to discuss about it. I turned off the no. 1 and 2 squib batteries and left no. 3 on and the main batteries on, and everything performed as designed. We also had carried along two adapters and about the time Jim said, "Hey, where's my adapter?" I realized where it was. It was stowed underneath a whole pile of trash on the right-hand side. So we went to Plan Bravo, which was our original plan before Chuck Berry sneaked on the extra adapter on the last day before the flight, which is a rather sneaky thing because we'd agreed at breakfast that morning that if the adapter were on the spacecraft, we wouldn't kick about it. But Chuck conversely agreed that if the adapter wasn't on, he wouldn't kick about it either. We later found out that he ran to Chuck Mathews and --

McDivitt No, as a matter of fact, he didn't run to him. Chuck Mathews said that he decided that on his own. Chuck Berry never--

White All right. I'll have to apologize to him because I have been falsely accusing him ever since. Anyhow, we had an extra one on, and it was stowed very neatly under a great deal of trash on the right-hand outside stowage box; and I felt that we could more readily use the time of switching back and forth. So we switched the aeromedical adapter back and forth, and with the microdot connector it was a pretty easy operational procedure. I don't think we missed any

radio calls, and I think we got probably more blood pressures there than one every 15 minutes.

McDivitt Yes, we would probably get one every 5 or 6 minutes.

White We were back on the carrier in 45 minutes, and I'm sure we had two or three blood pressures there on the water.

McDivitt You even got the lightweight headset on.

White That's right. I very dutifully put the lightweight headset on with my helmet off. I felt better with my helmet off, and I think you felt better with your helmet off.

McDivitt I felt a lot better with my helmet on and my visor closed, because I didn't like the smell of that stench there.

White I was so hot over there. I felt better with it off.

McDivitt We did a lot of work when we first landed. We were fiddling all over and getting things out of boxes and stuff like that. We probably did more concentrated manual labor in those first 5 minutes after we got on the water than we had done at any other time during the flight except trying to get the hatch closed.

White I think at this time I was completely drenched with sweat. I said it wasn't hot earlier, but with the combination of the suits and the fairly warm climate that we were in, I was sweating pretty heavy. I looked over at Jim, and he was pretty sweaty too, I think.

7.5 Spacecraft Status

McDivitt We didn't have any RCS fumes. We didn't see any RCS colored smoke, which is supposed to be red and purple or yellow or something like that. We didn't see any fumes at all. I saw a little steam.

White I saw steam.

McDivitt I saw a little steam coming out of the RCS thrusters, and I was sure that there wasn't any RCS propellant in those manifolds, because at the rate we were gyrating around with that tight deadband on rate command, if we hadn't burned all that fuel up by then, we never would have gotten it out.

White But we turned the RCS thrusters off at about 3 or 4000 feet. So they definitely weren't on.

McDivitt That's right. And we turned all the circuit breakers off on the RCS thrusters, so they shouldn't have been fired from shorts. The prop valves had been off at about 25 000 feet. So we had everything the way it was supposed to be, and we didn't see anything leaking. I'll comment on this window.

White I saw the main chute floating right to the left of us. I think my window might have been a little clearer than yours.

McDivitt I just was going to comment on the windows. My window was terrible! I couldn't see at all. Remember the helicopter was hovering around in front of us about 200 feet away and I never even saw it. You said, "Look at the helicopter!"

White He was a lot closer than 200 feet. He was right smack-dab in front of us.

McDivitt I never saw the helicopter. I couldn't see through the window.

White I'd estimate he was not farther out than 50 feet from us.

McDivitt I had a couple of little holes right down at the bottom where I could see swimmers down there, and I could see the nose, but I couldn't see up at all. We were talking about the main chute there. I saw the drogue chute floating down right next to it--drogue chute and the pilot chute with the R and R can floating down right next to it. They were coming down through about--let's see. We were on our backs then, weren't we? We still hadn't gone to two-point.

White I don't remember.

McDivitt I don't remember either.

White I was so busy taking blood pressures.

McDivitt We had the drogue chute and the pilot chute floating down with us for a long time just off to one side going down about the same rate. I thought that they were supposed to go down slower, but I guess it doesn't. I guess what probably happened was we saw them at single-point, but when we went to two-point, we lost sight of them. Okay. We didn't have any leaks that I could tell. We had electrical power. I didn't check to see what the secondary O_2 pressure was. Did you, Ed?

White No. I didn't.

McDivitt We turned off all our electrical equipment and couldn't read the gages. We left the hatches closed. We were in moderate seas, but I wasn't about to open those hatches up and take the chance of any water getting in that spacecraft. So we elected to stay in the spacecraft until they got the collar on, and kept all the hatches battened down.

White Okay, we both discussed this together and decided that the way we'd like to leave the spacecraft was in our suits, and we felt that rescue was coming pretty quick. We decided to go ahead and stay in our suits. I think this was a reasonable decision.

McDivitt We both took our gloves off to get the things out of the spacecraft that we wanted. I left my helmet on, and Ed left his helmet off. When we got ready to leave, we decided that we would put our gloves back on, take our helmets off, put our neck dams on, inflate our Mae West, and then get out. That's what we did. The sea condition was just like they said it was--three to four feet. Three to four feet in that thing is like 2000-foot waves to an aircraft carrier. We were bobbing around but we had a lot of experience bobbing around before, so it wasn't that bad. I might add that the egress training in the Gulf of Mexico really made me feel real confident when I was out there in that water all by myself.

White When we get to that training, I'm really going to give some gold stars out.

McDivitt Yes.

7.6 Postlanding Activities

McDivitt As I mentioned, we stirred around the cockpit and got out a bunch of little bitty things that we needed. We did a lot of work but we were doing all right. We got awfully hot. I guess we really can't say much about the postlanding activities. It went along as we expected it to, just the way we wanted it to. Ed, do you have anything?

White I think we've covered it.

7.7 Comfort

McDivitt I was hot. I think Ed was hot. We were both perspiring a lot. I think we could have lived in it for a lot longer than we did. Don't you?

White Yes. Did we cover the point where they called and asked what kind of rescue we wanted?

McDivitt No, I didn't. Why don't you? I was just plugging in the bio-med connector and I heard them call you.

White We could either have a helicopter pickup in about 20 minutes, or we could have a pickup by the carrier in the spacecraft in about an hour and 40 minutes. To me it was very clear.

McDivitt It took Ed a long time to decide--about 2 or 3 milliseconds.

White That's right. I felt that I knew my buddy well enough and made the decision that we'd take the helicopter pickup. I saw that he was actually on the radio at the time and he rogered the decision. So we waited for the helicopter pickup.

7.8 Recovery Force Personnel

McDivitt We had good communications with the recovery forces. They were on our frequency. We heard all the transmissions that were going back and forth. Shoot, we probably knew more about the recovery than anybody else around. They got the flotation collar in the water in a hurry and came over and put it right on. I saw this thing around the spacecraft and I saw it start inflating. I was really elated when I saw that thing pumping up.

White I had the first contact with the real live man.

McDivitt That's right. He looked in Ed's window to see if we were alive, I guess.

White Very good sight. The best sight, boy, was seeing that yellow thing around the spacecraft. I guess I knew we were going to be able to file out pretty quick.

7.9 Egress

McDivitt — As I mentioned earlier, we had decided to go out with our gloves back on and our neck dams on. I stood up in my seat, disconnected our survival landing gear (my other hoses were disconnected so that I could stand up), inflated both of the Mae West, snapped them together in the front, and I just jumped right over into the life raft. I landed right on my can, just like I had planned it. It was so good to get out of there. Ed got out. He jumped in too.

White — When I got out I actually leaped in before I inflated my Mae West and I think either you or--

McDivitt — I told you. As a matter of fact, when we talked it over in the spacecraft about getting out, Ed said, "Aren't you going to inflate your Mae West?" And I said, "Okay," and then he got out without inflating his.

White — I was so happy to see that raft I jumped right over the side.

7.10 Survival Gear

McDivitt — We didn't use any of our survival gear. We didn't pull it out. We just left it exactly where it was. I disconnected the lanyard so we wouldn't inadvertently pull it out.

7.11 Crew Pickup

McDivitt — As soon as Ed got into the life raft a helicopter came over toward us and I motioned for Ed to get into the sling and go on up. He didn't want to. He wanted to be the last man up, and I wasn't going to leave my sinking ship.

White — He wasn't getting up with the captain going first, so he went up last.

McDivitt — No. Ed got into the sling and got a nice pickup. I got a Gulf of Mexico pickup. He dragged me out of the water, bumped me up against the heat shield and the spacecraft, but it was a good pickup, though. Shoot, I was so happy to be out there in that nice cold salt water blowing in my face, I was dipping my hands in it and slinging it over my head.

White Did you notice the stability of that helicopter? I never knew they were so stable.

McDivitt Yes. He must have had a good stabilization system. They got us picked up safe and sound.

8.0 SYSTEMS OPERATION

8.1 Platform

McDivitt Actually, the first portion of any alinement is to cage the thing. The case of caging the thing is much more important than the alinement itself. In the daytime I felt that I could cage the platform to a reference with an error plus or minus about 3 or 4° in all axes. Did you think we could do that well?

White Only in the daytime.

McDivitt The yaw was a little problem. It took longer to get it, but if you kept after it for awhile, I felt that you could get down to just a few degrees.

White Within a couple of degrees.

McDivitt The big thing is that you have to stop your yaw rates, and then sit there and look outside for awhile and see which way you're going, straight ahead or sideways. If you are going sideways you rotate around for awhile and stop the rate and then look out again. Right? I felt you could get the thing caged quite well. We didn't do it BEF at all, did we? We never did cage in BEF.

White I'm not sure.

McDivitt The caging of the thing with small-end-forward in the daytime was relatively easy. At night I don't think it would be quite that simple. I think what you would have to do at nighttime is to point the spacecraft down at the ground pretty much so you can see the track across the ground. I could see which way the land was moving under me. I felt--although I never did this--that if I could do that and then roll around to where I had no bank angle, and face in my yaw direction, either small-end or blunt-end-forward, stop the roll there and pitch up to the horizon I could cage there within ± 10° for sure. It was much less accurate at night, I felt, than in the daytime.

White You aren't kidding! We both felt that on those dark nights when you really couldn't see anything on the ground, pure star reference for yaw was pretty rough.

McDivitt Pure star reference for yaw was almost impossible to use. That was the only place where that thing we decided not to take with us--the view of the stars through the window--might have been of some use to us. We knew the stars along our track but you couldn't see enough of them. The quickest way to get the yaw reference was to look down at the ground. Once we got the platform caged, alinement was quite simple. All you had to do was just hold the needles at zero and the platform alined itself. Of course you had to have the scanners on. The modes--the SEF and the BEF were identically the same except the spacecraft is pointing in different directions. You tended to null the needles by using pulses and just hold the needles very close to null, and the platform alined itself through the horizon scanners. Orbit rate was a satisfactory mode, I thought. As a matter of fact, it was very good.

White I liked that orbit rate.

McDivitt Yes, because we finally had a reference where we didn't have to look out and see the ground. It's like having the old altitude indicator back in an airplane. The only thing was, we had the wrong orbit rate in the spacecraft because it was set for an orbit rate that was to take care of, I think, a 60 nautical mile circular orbit. This was to take care of the short period of time between going to orbit rate at T-5 and firing the retros at TR. We wanted to have exactly the right rate in there so when we did our closed-loop reentry we wouldn't have an error. As I said, I had the most accurate platform in the world with nothing to do with it. I think the displays were adequate and the controls were adequate. After the first couple of revs I really didn't have any confidence at all in the platform. I had done nothing to establish any confidence in it. I really didn't get the chance to get the thing alined, and I really didn't have the view out the window to check it with. We were hurrying and scurring through there. We finally shut the thing down before I really got a chance to use it very much. When we powered it up there on the third day, and we saw that thing coming around there and cage properly, we compared the out-the-window attitudes and that old attitude reference was right there. That's when I got some confidence in the platform.

White This is where we lost a couple of bets.

McDivitt That's right. We lost a couple of beers on that platform. At retrofire I had a lot of confidence in the platform,

but the first two and a half to three days I really didn't have anything with which to establish any confidence. It was just an unknown.

White Jim did the majority of the work in this area, and I think his comments reflect my opinion also.

8.2 OAMS

McDivitt On the pad we did the thruster check that we wanted to. We went around one whole cycle and got nothing. We went around another whole cycle and got nothing until we got to the last one. We were going yaw left pitch-down, yaw right pitch-up, Yaw left pitch-down, yaw right pitch-up. When we got to that second pitch-up, I heard the thrusters fire for the first time.

White You can hear them. It was very distinct.

McDivitt That's right. And then we went around and yawed left, and they fired again. We waited 20 seconds and fired the yaw left again, and they fired again. These were the bottom manifold jets. We said, "Okay, we're ready to go," and that was the end of it. So, it was a pretty straightforward check. The inflight checks--I got my operational checks on the OAMS systems while chasing the booster around. I had direct, pulse, and rate command in there as I chased it around, and those were the only modes I intended to use right then. Later on, I checked out the Reentry Rate Command, and I checked the Rate Command before we thrusted. It did seem to be operating fine. Why don't you go through the next part, Ed?

White All right. We're going to get into the source temperature and pressure, the regulated pressure, and the propellant quantity. Let's take the temperature first. The temperature of our OAMS was 75° all the way down the line. The initial indications on the pressures were approximately 2800 psi for the source and 320 psi for the regulated pressure.

McDivitt The quantity gage operated all right except that, as I mentioned earlier, the thing seemed to wander up and down somewhere between 2 and 4 percent, depending upon where you were in the mission. You'd read it one time and it would be 60, and you'd read it a little while later and it would be 62, and you'd read it a little while later and it'd be

back about 60. The greatest variation in that thing that ever occurred was when I went to sleep one time with it reading 60 and woke up and it was reading 56. Another hour or two after that it had climbed slowly back up to 60 again. I had a long time to look at it in the same position. When we ended the chasing-around at the end of the first hour, we were down to 70 percent indicated, and we never got below 50 percent in 4 days.

White I'll tell you, the position it seemed to stay for days and days was 59 to 60 percent. We fired in Pulse Mode for a long time with the gage at that position, and all of a sudden that one time it dropped down to about 55 percent.

McDivitt But then it came back up to 60.

White I guess it did, didn't it? The temperatures all stayed fairly constant. If I recall right, they dropped down to around 70°. It seemed to me they continually decreased throughout the flight. I noticed this particularly in the RCS, but I guess we'll get to that later. The propellant quantity though, I think we menticned earlier, ended up on our gaging at about 3 percent at the end. We got a bittle bit of ground information on the OAMS propellant. I felt a little suspicious of the gage when it kept staying there at 59 to 60 percent for so long.

McDivitt We were pretty miserly with that OAMS fuel. We set out to save the fuel and we sure did it.

White I think that in future missions, if they permit the crew to use the Pulse Mode in a saving-manner, they could do a lot more with the mission--if you could use Pulse Mode instead of just free-drifting around. In other words, line yourself up so you can make some decent observations.

McDivitt Shoot! We were in Horizon Scan Mode when we got the last data, and I don't think we used any more fuel than we were when we were in free drift.

White That's right. We certainly got more out of the orbit than we did when we were just drifiting free.

McDivitt I'll tell you one record that we ought to hold. We've looked at the earth from more different angles than anybody else in the world. Well, maybe not. I guess the Russians did, but we sure got a lot of different views of that earth as we rotated around.

White I think the ground information that they called up on the status of our OAMS wasn't as much as they could have called up to us, but I'm really satisfied that our OAMS was staying pretty constant.

McDivitt So did I. The way I felt was that I knew that we had to be as miserly with the fuel as we possibly could, so we got as much out of as little fuel as possible. There wasn't going to be anything to change that velocity. We just went along and I really didn't care how they were plotting that fuel on the ground. I knew that we were starting to get ahead of the schedule, because I was plotting it roughly onboard the spacecraft. I could see we were up above the line that we needed to remain above to handle our OAMS retrofire.

White Actually, we followed the profile rather closely. We leveled off there at first, and then when we started using it, we went right down the profile.

McDivitt We were a little below the line, and we just held the same fuel level until we walked out across it and got up on top of it. Then, we went on down above it.

White I think the controls and the switches were all satisfactory.

McDivitt I think so too. The attitude controller worked fine and dandy. We didn't have any trouble with it. The stick forces weren't too high. We didn't get a chance to use it in any other mode besides Pulse. It seemed to work all right in Pulse. I don't really have any comments to make on the attitude controller.

White As a matter of fact, I didn't use any rate command.

McDivitt Didn't you really?

White We didn't use the Rate Command. I got to use Direct a couple of times. I used Pulse a lot. Everytime you'd go to sleep, I'd really have a ball!

McDivitt I could tell that by the wiggling.

White No. That was really great--flying that spacecraft.

McDivitt That's right, and I think Pulse is the mode. You can do a lot with it. With a little bit of planning you could get to the attitude--if you start out 5 or 6 minutes ahead of time.

That's what we were doing. At 10 minutes before I was supposed to be at a certain attitude I'd start, and one or two little pulses and you'd--boop, boop, boop, boop--. The bad thing was if you were in an attitude where you couldn't see the horizon and didn't know where you were. You would give it a couple of pulses and nothing would happen, and you'd have to give it a couple of more pulses. It'd take a long time sometimes before you would get to where you could see. As a matter of fact, if at 5 minutes before we were supposed to be at a certain attitude we weren't approaching it, I'd start pulsing a little harder.

White You'd hear a series of about five quick pulses.

McDivitt It was a very economical control mode. The maneuver controller worked the way it was supposed to.

White What about the deadband? Did you think the deadbands and breakouts were all satisfactory?

McDivitt Yes, just like the one we used in the simulator. You've got a lot of slop in it when you're making gross maneuvers because you're not fixing your elbow and manipulating around that point. You're fixing your shoulder and your whole arm, and it's just like shoveling coal--you've got about that much finesse to it. I don't think there's much you can say about it. The controls weren't too gross and they weren't too minor. The whole thing was adequate. We did have an inflight malfunction, or irregularity. We were in Horizon Scanner Mode one time and Ed wanted to yaw around. He started to yaw and the thing rolled. The Horizon Scanner Mode fired the roll thrusters to level it back off--

White I couldn't get the yaw. We had a circuit breaker off.

McDivitt Finally, after you did that a couple of times, I looked up and saw we had knocked a circuit breaker off. That was one thing that we didn't cover in EVA that I should have mentioned. Ed was a real hazard to the switch positions in that he was all over with his feet, arms, and hands--.

White I don't think I threw any though. Did I? Come on now. You're not guilty until you're convicted.

McDivitt I don't know. You kept putting your foot on the HF Reentry Antenna Switch and stepping on it. Ha. Ha. Ha.

McDivitt As for the attitude control modes--I mentioned the rate command in OAMS seemed to be tighter than the Rate Command in RCS, although they use the same electronics, the same gyros, and the whole thing. It might have just been my imagination, but I felt that the Rate Command system in RCS was a lot looser than it was in OAMS. The Reentry Rate Command operated just the way it should. It had a 4° deadband, and handled the spacecraft very well during reentry. Direct had a lot more authority than I thought it would, but it was pretty straightforward. I think Pulse was the best mode on the spacecraft for the orbit phase. We were able to save all kinds of fuel, it worked fine, and it was just about what the doctor ordered. We didn't use the Horizon Scan Mode during about the first 3 days of flight, except for the second orbit when I think I was in Horizon Scan so that I could have the freedom to help Ed prepare for his EVA. The last day we used the Horizon Scan Mode, and I found it to be an excellent mode. There was only one case when it broke lock and didn't recover. Wasn't that it, Ed?

White You've got it in the book.

McDivitt We've got it in the book, and we'll check on that. The Horizon Scan Mode worked essentially for 24 hours without any problem and I think it's an excellent control mode. It seemed to be very economical on fuel. We were doing a lot of yawing around and right at sunrise and sunset it seemed to get a little nervous, especially if we has the Horizon Scanner pointed within about ± 45° of the sun. The moon didn't seem to affect it at all. I noticed that, occasionally, we would get some thruster blips with the sun pointed toward the horizon scanner although we never got an unlock light. We wouldn't get an unlock light, but we'd get a bunch of maybe four or five thruster blips right there.

White Particularly at sunrise.

McDivitt It would hold. I thought the Horizon Scan--

White It was definitely getting some spurious signals through but not enough to break it out all the way.

McDivitt I thought the Horizon Scan Mode was an excellent attitude-hold mode.

White Did you notice the water boiler venting, Jim?

McDivitt Yes, I did. We kept yawing around to the left. I believe it was left. I did notice the fact that we were yawing, but not very much. We were yawing at rates that were extremely low and it just took a pulse every once in a while to handle the thing. As a matter of fact, when we were chasing the booster around a lot at the beginning, I never even noticed. It was when we were in the Pulse Control Mode for a period of time, when we didn't do much thrusting in yaw, that I noticed we did start drifting off in yaw. So I did notice the water boiler venting.

White I didn't think you noticed it earlier when we were working.

McDivitt Well, I did notice it a little bit in that first orbit, but it wasn't distracting at all. It would just drift off a little bit and I'd whop it and it would be back. At SECO+30, I used the translation thrusters to damp the booster-spacecraft rates. One of them was a little higher than the other, although they were both down in the order of a half of a deg/sec. I did fire one thruster one time or possibly two times, to damp the rate. I don't know if it was pitch or yaw. You know, you are working in spacecraft pitch and booster yaw and spacecraft yaw and booster pitch. I was getting my coordinate system transformed around in my mind, going from booster coordinate system to the spacecraft. I don't remember whether it was yaw or pitch, but I did thrust once or twice. By the way, I could hear those thrusters fire. At SECO+30 I said, "Thrusting," and I started thrusting. "Separate," and Ed punched the SPACECRAFT SEPARATE. We were in Direct, and I thrusted straight ahead for about 5 seconds. Then I went back into Rate Command. Separation was just smooth--we didn't come off with a rotational rate.

White I think one of the things you might comment on, Jim, is that you fired most of those thrusters during that initial time.

McDivitt I'm sure I fired the upward-firing thrusters a number of times. That isn't any more difficult to control than the other one. Actually you can fire these thrusters whether you are in Rate Command, Direct, or even in Pulse. When you fire them, you get a rate and you just damp the rate out with the attitude controller. When you are firing the translation thrusters, the things that you really hear are not the translation thrusters, but the attitude thrusters. Those translation thrusters are really tough to hear, but the attitude thrusters are very easy to hear. I don't understand why. They must be mounted differently because their location isn't that much

different. I think I fired the aft-firing thrusters a couple of times, and they didn't make any more noise than the forward-firing thrusters, that I could tell. The up and down and left and right ones were just as easy to fire as the other ones. Our OAMS retro was 127 ft/sec which, incidently, happened to come out exactly 2 minutes and 40 seconds. I suspect that we selected OAMS retrofire on the basis of time, rather than on the basis of ΔV.

White Very convenient, wasn't it?

McDivitt Very convenient. It was obvious there is no more difficulty in timing 2 minutes 40 seconds during our OAMS retrofire than it is during any other thing. We had no trouble with it. I was convinced that when we got through with it, that was really the proper conversion factor between ΔV and ΔT. We had exactly 127 ft/sec, and we sure had the time nailed down.

8.3 RCS

McDivitt The operational checks that we did on the RCS occurred at about TR minus an hour. When I checked the system out it seemed like I had a lot less authority and a lot sloppier Rate Command than I had in OAMS. The operational check consisted of pitching up and down, yawing left and right, rolling left and right on each ring in Rate Command and Direct. Direct worked as I expected it to. In Rate Command, however, as I pitched up and down I noticed that my top left yaw thruster was doing a lot of firing too. I started out checking the Rate Command, so I thought I might possibly have one bad pitch thruster that was causing a rolling moment that was being counteracted by the yaw-roll jets. When I did it in Direct, however, it wasn't doing that. It wasn't rolling either, so I felt that it must just be a very tight deadband that was trying to hold us in there. So, the operational checks were all right. The only thing we had to monitor on the system was the temperature and the pressure of the propellant. It seemed to hold pretty well.

White I have some comments on that. I kept a running log of them as we went along. The temperature started out at 75° and 3000 pounds. It held that way pretty well until about the 65th hour, when the temperature gradually went down. The temperature decreased to a point where we started getting the RCS heater lights that we noted earlier. We got about

eight series of RCS heater lights. It took about 5 minutes to extinguish the light. It was the A-ring, then the B-ring, and then the A-ring. It seemed to alternate each time back and forth and it came on for about 15 to 20 minute periods of time. It started right after a night cycle. It seemed rather natural to me that there wasn't really something wrong, but that we actually had a cold RCS thing out there and it did need some heat. After heat was applied it did appear to go away. I decided to go ahead and set up a slow roll rate in the daytime, and I kept that roll rate in for several orbits. Whether this actually helped to get the light off or not, I don't know. We didn't get anymore lights after this time. I think there ought to be one other comment on the RCS, and that is the temperatures and the pressures stayed up pretty well except when we actuated the system. The pressures then went down further than we had expected them to go. They went down to 2400 to 2500 psi. This was a little lower than I expected to see.

McDivitt I think the pressures in the RCS A and B dropped by about 100 pounds throughout the 4-day period. They were slightly over 3000 pounds and they got down to slightly under 3000.

White The lowest temperatures I noted were in the neighborhood of about 63 to 64°. They started out at 75°.

McDivitt Let me ask you a question?

White Yes.

McDivitt When you turned on the RCS heaters, did you turn on the heaters on both rings, or did you turn on the RCS Heater Switch and then turn off the circuit breaker on the other ring?

White I turned the heaters on and then I checked to see which ring it was that was actually heating up by using the circuit breakers. The first time I went ahead and left them on and then the other ring came on. I felt that one of them was about as cold as the other, so I left the heaters on both rings throughout the heating cycles.

McDivitt Good.

White They were in perfect sequence--A and B, A and B, and about 15 minutes apart. The regularity was surprising. The temperatures at the time when these lights came on were indicating about 63 or 64° and it seemed like it would come up

a little bit, and then come right back down and pop back on again. I felt it was not an actual temperature problem.

McDivitt I used Rate Command, Reentry Rate Command and Pulse control modes. I didn't use Direct. They all operated as I thought they should. I've already mentioned I thought Rate Command was a little sloppier in RCS than it was in OAMS. It certainly did a fine job of holding the retro attitude during retrofire. Retrofire attitude control was excellent. We didn't deviate more than about a degree from the attitude we were supposed to hold, and I had plenty of authority there. From my standpoint it couldn't have been any better. I was really happy about it. I used the Reentry Rate Command with roll rate gyro off, so that I had essentially Direct in roll and Reentry Rate Command in pitch and yaw axes. It had the typical 4° deadband that it was supposed to have. It did do rate damping as it was supposed to. It performed just the way it should. Ed, you want to cover that heater-lights thing again? I think you've already got that thing pretty much in detail.

White I have the precise times at which the lights came on. It started at about the 64th or 65th elapsed time hour. At 06:47, the first light, in the A-ring, came on. At 08:23 the A-ring light came on again. That was the last time. During that period of time the A and the B-rings cycled on and off intermittently.

McDivitt During descent, we turned the power off to see if the drogue chute was unstable. It wasn't. We turned the power back on and the propellant valves off and burned up all of the fuel in the manifolds. We had no fumes after impact.

8.4 Environmental Control System

McDivitt I thought the suit mobility was as good in the spacecraft as it is anywhere else. I think these suits are pretty good suits. I didn't find any trouble with them whatsoever in the spacecraft that I wasn't already aware of. The pressure held up good. I did a pressure check on the suit. It bled down about 0.2 or 0.3 psi in about 30 seconds, which really wasn't too bad. The temperature was always good. It ran between about 50 and 55° during the entire flight, except when we really worked hard. I don't think it ever got up over 60. Do you, Ed?

White No.

McDivitt We had reasonably good temperature control.

White The cabin temperature got up pretty high one time, and then it came back down.

McDivitt Yes, on about the first orbit.

White That's right. It got up to about 90.

McDivitt 100, it was. We turned the cabin heat exchanger on for just a short time, and it went right back on down to 80°.

White It stayed in the area of 82 to 83° the whole flight.

McDivitt The humidity in the suit must have been pretty dry because my foot dried out. I didn't take any wetbulb readings inside the suit. The CO_2 stayed at zero all the time. It never did go up except when we'd go to O_2 High Rate, then it would bound off the top peg and fall back down again. The comfort and suit controls were pretty reasonable. The O_2 demand regulator seemed to work all right. My umbilicals were short. My fingertip lights were lousy. Before launch I only had one that worked. On my right-hand glove one of the bulbs obviously didn't work. One of them did work. On my left-hand glove the switch on the batteries would only turn the lights on if it was in one exact position, which wasn't full throw in either direction. So I found out I had only one fingertip light that worked. However, during the flight I didn't use my fingertip lights except one time when I used them for a flashlight. I had my gloves off and I reached over and got my gloves and turned the fingertip lights on, and shined the gloves on something. I didn't use them a lot. I do want to comment on one thing, though, since we're talking about the suits here. I launched without the plug that goes in the blood pressure port in the suit. I don't feel we should launch these things with no plug to plug up the blood pressure port in the suit, especially when we're going EVA. I think that was a mistake. The only pressure points I had in the suit were in the helmet. Those were just above my ears where I tended to move my head back and forth within the helmet. I finally rubbed up all the hair so that it was going in the wrong direction. When you press against hair for a long time in the wrong direction,

it becomes very uncomfortable. At about the end of 2 3/4 days I took my helmet off for a couple of hours, and it felt a lot better. The only problem is that when you have your helmet off there is no place to stow it. We had the foot wells full of gear, so when I had the helmet off I just let it float around on my lap, and over in Ed's lap. There wasn't any place to put it. The micrometeoroid blanket that I had strapped under my right leg wasn't a detriment. As a matter of fact, since we had no place to stow it, I just left it strapped to my leg until reentry. Then, I felt that if we had to get out in the water, I didn't want to have any straps hanging off me that I didn't need. So, I took it off and threw it on the floor along with Ed's sleeves. I don't have anymore comments on my suit.

White I wore the EVA suit. I think the mobility of the suit was about what I had expected. Actually, I think the mobility in some respects was a little better, and in some respects it was a little less than I had expected. I wasn't able to get into the right-hand aft food box as well as I had thought I was going to be able to in zero g. In fact, the position that I had figured out to use, which was leaning forward and reaching in backwards with my left arm, didn't work out well at all. I had to actually turn around 90° in the seat and reach in with my right arm. This worked out all right. I was able to get hold of things in the box. The surprise that I got though, was that I could get into the right-hand aft refuse box much easier than I had thought I'd ever be able to. It turned out that I was able to get into that box easier while in orbit, by far, than--

McDivitt It's a rubber covered box.

White It's a rubber covered box on the right hand side. I think that box does have the capability of stowing refuse in it and stowing some things prior to launch in it, too.

White Did you try that box during flight, Jim?

McDivitt Yes, I did. I didn't find it easy to get into. I thought the things we had stowed in it were real good things--items that we didn't need at all in flight and possibly might not need--

White I used all four defecation bags that I had on my side. I used them up during flight. In fact, you used one of them.

McDivitt That's right, we did have a bag of those defecation bags out. It just happened to be over on my side where you could get to it.

White You were asleep. I had to get them or wake you up. I pressure-checked my suit. I checked it at 8.5 and it bled down several tenths of a psi. I was satisfied with the pressure-holding of my suit. There was one thing though with the suit that I wasn't too happy with. I was hot all the time in the suit. It got so that after a while I got used to the normal temperature as being warm. I could increase the temperature, which seemed rather strange to both Jim and me, by putting out my gloves and closing my faceplate. I could go to sleep. At that time my temperature would go up considerably inside the suit. It seemed like I could stay in there only an hour or an hour and 15 minutes and rest before I had to either open up the faceplate, or do something else. So, the temperature got uncomfortably warm in about an hour or an hour and 15 minutes with the faceplate closed, the sleeves on and the gloves on. The humidity in the suit, I thought, was quite dry. I had quite a tendency for my lips to crack and my nose to get very dry. In fact, I noticed my nose was itching considerably. This was an indicator to me every time I would go to sleep. I would wake up with my nose itching and feeling quite hot and uncomfortable. My lips got to the point where I thought they were going to crack, and I was trying to be very careful and keep them from cracking and getting anymore uncomfortable than they were. Jim mentioned the CO_2 sensors stayed on zero, which I was happy to see. I think one thing that I was fairly happy about was that the suit, as bulky as it was, wasn't depressingly uncomfortable. I felt that I did have a pretty heavy suit on most of the time, and I was a little bit constrained in my mobility. The idea to have the detachable sleeves that I could take off after the EVA work was, I felt, a very good decision. I felt much more comfortable, and I had a much higher degree of mobility around with my arms in the spacecraft. It was not as tiring to move around as it had been when I was inside the heavy sleeves. So, I was quite happy to take them off. We took them off, I believe, shortly after my first sleep. I slept with them on the first time, and then we took them off. I think they were quite easy to take off. As a matter of fact, I think if you went EVA at a later time you could take those sleeves onboard, and if they were made just a little easier to slip on and off over the wrist, you could take them on and off in flight if you wanted to.

McDivitt I don't know. I'd hesitate to recommend putting them on in flight. It might get pretty tricky. I think if you put them on in flight, you'd want to put them over all the harness, rather than under the harness.

White That's exactly what I was going to say. I think if you took the life preservers off, you could actually made the sleeves big enough so that you could slip them on and velcro them across the back over the harness. This might be for the type of operation of throwing equipment in and out. I think in the future, though, a suit as heavy as this might not be required. The controls and the switches in the suit, I felt, were satisfactory. There wasn't anything that I couldn't get at in the spacecraft. It was easier under weightless conditions for me to operate certain controls. In fact, I think I was able to get down and unscrew the bellows in the gun hose as well as maybe a little easier than you could, Jim. At least initially, I was able to get down there. Of course you weren't really particularly trying to do it at that time.

McDivitt I suspect I probably could have gotten down there as easy or easier than you, if I had really gotten around to trying.

White I don't remember, but, anyhow, I was surprised with the ease which I had in getting down.

McDivitt We were trying to dump the pressure in the bellow before we went EVA with it.

White Right. The demand regulator was satisfactory. My umbilical; I thought, was very easy to use and disconnect. I was quite happy to have the micro-dot in there. One comment on the micro-dot--the first time we exercised the micro-dots on our suit, they were pretty hard to operate. Mine got progressively easier to use each time I used it. The fingertip lights that I had were better than Jim's. I had lights with Lexan tops on them. All my lights worked, and I felt that their operation was quite satisfactory. We had decided to put my lights between the first and second joints for several reasons. We thought the EVA gloves would be easier to don and there'd be less tendency to break them. I think, though, the position of the lights was still a little too far forward, if it was intended to put them back between the first and second joint, because the lights were resting right on top of my first joint. I think if I had worn my gloves any more, I would

have gotten a very sore first knuckle. If you are going to move them back, I think they should definitely be moved back behind the first knuckle.

McDivitt Where were they getting you, Ed?

White Right on the top of the knuckle.

McDivitt You think they ought to be back?

White If they are going to be anywhere, they ought to be back here, and I'm not too sure that is necessary. In fact, I think the best place is behind the fingertip and in front of the first joint.

McDivitt But, with the plastic covers over the gloves.

White With the plastic cover on the glove, and I think we've got the right position for the lights. I don't think they should be back behind the first knuckle. I think they should be in front of that first knuckle and behind the fingertip. That's a good place for them. That's where we've been using them in the past. I think the Lexan cover on the light bulb is a darn good idea.

McDivitt Yes, I think so, too. Shoot! I checked my lights before launch and found out that I already had one of them out on my right hand. I wasn't too happy about it.

White I was a little disappointed. I think the only discrepancy I found in my suit was that I had no blood pressure plug either. A point that I was pretty happy with was that I had no pressure points from my suit at all on my body. I had one set of pressure points from my helmet pressing down on the front forward part of my head. I knew why this was. I'd had Joe Schmitt adjust my cables so that I could pull my helmet down to a maximum amount for the EVA work. I felt that I just bought this discomfort by having my cables adjusted in this manner. It was pretty uncomfortable though. I checked out the use of the emergency bottles on the EVA equipment, and they worked as they were supposed to. I was able to regulate the flow. Incidently, before I went out, the reading on the EVA bottles was full-scale, 3400 pounds. I was happy to see that. All in all, I was quite happy with the suit. I think it was a very well designed suit, and it met the requirements that were levied upon it. It was a heavy suit and a big suit to wear for 4 days, but I felt the suit wasn't as bad as I had

expected it was going to be. I have one more comment. I'd like to comment on the inner liner. We decided to go with the inner liner in, and I felt this was a good decision. The inside of the suit was comfortable, and I didn't get any pressure points. I think one reason why neither Jim nor I got any particular pressure points from the suit was that we had worn these suits a heck of a lot of time. I had over 50 hours on my flight suit. I don't know how many hours Jim had on his.

McDivitt Actually, Ed had just finished talking about his inner liner. I'd like to comment about the inner liner too. I thought about it when he was talking about his. I think that was one of the really wise decisions--to go with that inner liner. I felt that it offered a lot more comfort than wearing that rubber suit up against my body, or up against my underwear. I sort of felt that I was really quite comfortable in this suit. I didn't find my mobility limited by my inner liner at all, and I had made sure that it fit. I think that had a lot to do with it.

White I worked the suit once for about a four-hour period with just the rubber inside. I did notice it sticking to me, and I didn't feel as comfortable. After I got inside the suit with pressure on my body, the suit felt pretty darn good. I had the knees cut out of my suits. The knees are still too short. Having been in it for 4 days, I know the dimensions are wrong. The dimension from my knee down to my foot is not long enough. It's not just the inner liner, but the link net in itself just isn't long enough.

McDivitt You wouldn't say you had a pressure point though?

White No, it was just a constant pull on there all the time.

McDivitt Did it bother you very much during the flight?

White Yes, it bothered me a little bit.

McDivitt So you really did have sort of a pressure point then?

White Yes, to some extent in that area. I had had that one so much before. It had been so extreme in some cases that it really didn't bother me to much.

White Both of us should mention something about the visors.

McDivitt I thought you ought to mention something about your visor problem, your EVA visor or the other one.

White Well, I have briefed the visor on the EVA pretty well. The one that I will mention now is the visor that I had on my regular helmet. I thought that the vision through it was quite good. I noticed no distortion at all through it, but I did immediately put a couple big scratches on it in the beginning, when I was unstowing equipment. I continued to scratch it throughout the mission. When I finished, the visor was considerably scratch up, as you would probably notice if you looked at my suit. I don't know what there is to do about this other than to accept a scratchy visor.

McDivitt If you've got the visors down in front of your face, you don't tend to scratch it up as much. I think it was really worn out because you started opening up your visor and leaving it up over your head a lot earlier than I did. At about the two and a half or three day mark, I looked at your visor, and it was really a mess. I took the helmet off and cleaned the visor because it was dirty on the inside and the outside. I looked at my visor and had very few marks on it. I had a few little scratches, but very minor. Then I started putting my visor up more and more because they wanted us to stay open. Because I'm a lot taller than you are, I really started beating mine up. In the last day, I think I caught up with you and maybe even surpassed you in the amount of marks on it. I'll say another thing. I'm sure glad we didn't go in for those Lexan visors that they wanted us to fly with, cause the distortion would have driven me batty in about the first 6 hours.

White I think you must insist on perfectly optically clear visors.

McDivitt That's right. You've got to have good optics.

White I took my helmet off about three times, and I didn't leave it off very long.

McDivitt I took mine off about two times. I took it off one time for an hour because my hair right above my ears was really bothering me. I didn't bother getting a light-weight headset out, and when anybody called me, I had the thing sitting in my lap and I could hear it. I took one of the ... and pulled it back and I hollered into the mike, Ha, ha!, till I could hear it. I said, "I've got my helmet off. Unless you've got something important to tell me, don't bother me." Ha. ha!

And he said, "Okay." It was one of those passes, you know, where you only talk to one guy for about an hour. Then I took it off one other time for about a half hour to rub my ears. I was quite comfortable with my helmet on for 2 days.

White Do you want to know something that's kind of strange? I was more comfortable with my helmet on than off. In fact, I kind of got used to those pressure points on the top of my head with the helmet on. When I took the helmet off and moved my head around, I felt a little dizzy from not having those restraints. I didn't feel as comfortable as I did with my helmet on. The times I had my helmet off were when I was running D-9. I ran the D-9 Experiment several times with my helmet off so I'd have better use of my sextant. I took it off one other time near the end when they indicated they would like to have everything off. I didn't feel particularly comfortable with my helmet off any more. I got so used to having that thing on that I put it on so I could talk better with the stations. They were calling me from time to time, and I thought it would be a little better. Before I forget, I think the portable headset is really a lousy design.

McDivitt I concur. I think it ought to be thrown out.

White I've seen the ones they've got in the MCC, and they're good plain old headsets. I don't see any reason why we can't get one that stays on your head and stays in your ear. You put this thing on, and it pops off about two minutes later. It's not built to stay on my size head, and I noticed it didn't stay on Jim's very well either. I think the portable headset idea is a good idea, but we ought to have a good headset for it. Okay. As we mentioned earlier the cabin pressure relieved at about 5.5 and held that way during launch. It went back down to 4.9 or 4.8, and this is where it stayed for the remainder of the mission. I think that they probably overshot their zeal to correct the cabin pressure that John and Gus had had on GT-3 and put ours down so that it was actually relieving lower and sealing lower than it would have been desirable. I was expecting it to seal up around 5.5 or 5.7 like it was advertised.

McDivitt I checked my suit gage against the cabin pressure gage and my suit gage read higher than the cabin pressure gage by about 0.3 of a pound.

White Yes, mine was right on it though.

McDivitt I know. You checked your suit gage against the cabin pressure, and your read just about on it, didn't it? Was it a tenth of a pound higher, or was it right on it?

White Right on.

McDivitt Okay. So mine was reading a little higher, indicating to me that possibly the cabin pressure was higher. But since Ed's read with it, I don't know where we were.

White Well, the pressure at which it relieved at went right into the problem of the temperature-pressure relief in the cryogenic oxygen system, so that those two problems kind of lashed together. The venting in the O_2 system was set at around 970.

McDivitt 967, I think the poop sheet said.

White Well, it was about 967 or 970. We had the possibility of losing oxygen in a steady manner out of the spacecraft if we let the pressure rise up above--well, the ground felt 960, and I concurred with that figure. So throughout the flight we had to keep venting our O_2 system down so the pressure would remain down below 960. They initially told us to vent it to keep it at 930 to 960. Then they told us to vent it on down to about 890. From then on, we vented it down in the neighborhood of between 890 and 93, depending upon who was asleep and who wasn't asleep. It sure seemed to be an unsatisfactory solution to two problems--one of the cabin holding at a higher pressure than they wanted it to on GT-3, and also the problem of the O_2 system venting outside of the pressure gage. In the oxygen system I think the solution to putting the venting down at 967 was a poor solution to the problem of having a poorly designed gage. I think the gage was again poorly designed, and it should be designed to read about 1200 pounds. Relief should be up in that area.

McDivitt If they really went ahead and jacked down the relief pressure, to get it on the gage, I think that is one heck of an approach to an engineering problem.

White I think that's a gross thing to do and if they did that diliberately, I think they deserve a very black star for that one.

McDivitt They need their heads examined!

White I guess we beat that one around pretty well, didn't we?

McDivitt Yes. The way that we were venting the cabin was by going to O_2 High Rate and venting the oxygen out through the cabin vent, or going to cabin repress and using up the oxygen through the cabin and through the cabin vent valve that way.

White I was quite satisfied with the cabin temperature. It started out and got pretty hot at one time early in the flight and went up to 100 as you noted, and then it went back down into the 80's. I think it actually dropped into the 70's a time or two.

McDivitt That's right. It was in the 70's most of the time.

White Right.

McDivitt Let's get the data book. The dry bulb temperature was 80; 80, the first time we took it. Then it was 79, 79, 79. Then it was 75, 75, 75; and then they stayed between 75 and 77, I think, the rest of the flight. No, here it is down as low as 72. So it got down to around 72 late in the flight, and here we are with a whole bunch of 70's to 73's and a couple of 76's. So I guess that 75 was the average temperature throughout the whole flight.

White I think our cabin temperature gage was reflecting a little higher temperature than these.

McDivitt No, let's see. It was down around 75.

White It went down to 74 at one time, I remember.

McDivitt Yes, I think 75 was a good average cabin temperature for the whole flight.

White I thought this was a pretty satisfactory cabin temperature. The suit temperatures were also down. They stayed down from about 52 to 54 most of the flight. I thought that was a pretty satisfactory temperature there. I believe that there was a difference in suit temperatures between Jim and me because I was continually hollering about being hot. I think that temperature-wise Jim was relatively comfortable.

McDivitt I was very comfortable and, as a matter of fact, when I went to sleep, I tended to get just a little bit cool, especially if I had urinated all over myself.

White I don't remember one time during the flight during which I was cool in the suit. I think I was hot most of the time in the suit. I got used to it after a while. The only time that it was not satisfactory, as far as I was concerned, was when I was trying to sleep. The humidity data that we got doesn't go along with what everybody was expecting.

McDivitt No, not by a long shot.

White No, not at all. Our little gage seemed like it was working properly. We didn't have any visible moisture at any time at any place in the spacecraft. It seemed to be indicating down around 62 to 63 percent relative humidity which was a big surprise to myself. With this type of data, I began going open faceplate and open gloves fairly early in the flight, about a day or a day and a half, and continued in this manner just about throughout the flight. We used the wrist dams quite a bit of the time. But I had my faceplate open with my wrist dams on a great deal of time also. I think you had your faceplate closed a little more than I did. There at the end we were both going to an open-faceplate and open-gloves all the way.

McDivitt Yes, we were especially going open-faceplate at the end just to see if we could jack up the humidity. I actually preferred to have my faceplate closed, as opposed to having it open. I went ahead and left it open trying to get the humidity up. We never really did get it up over 60 percent. That seemed to be where it was going to stay.

White We were happy to see that the CO_2 sensor gage stayed down low the whole flight. It would pop up any time we turned the O_2 High Rate on and go up to a pretty high reading, and then settle back down to zero. I didn't notice any particular discomfort versus day versus night.

McDivitt No, as a matter of fact, I didn't either. We took some temperature readings on the cabin window frame, and they varied by about 6 or 8, 10° at the very most.

White Yes, I don't think there was any discomfort associated with day-night cycle. We didn't use the cabin fan as we planned during the flight. We did neglect to turn it on initially during the preparation for retro. We noticed that we weren't cooling off in the cabin as much as we would have liked to. So, we turned the fan on and immediately the temperature dropped down about 10°, if I remember right.

McDivitt Yes, that cabin heat exchanger and that cabin fan really do the job.

White It really cooled it off.

McDivitt Early in the flight when we got the temperature up to 100, we turned the fan on, and the temperature went down to below 80 in about 20 minutes or so. It really did the trick.

White The cabin pressure relief valve was venting just a hair above 5.4. We checked this out very many times. Every time we filled the cabin up with O_2 High Rate, it vented, or if we used the repress lever, the cabin would vent.

McDivitt Here we had an environmental control system that was supposed to protect us. We found out that the darn thing was overpressurizing. The first couple of times, to keep the ECS O_2 bottle from venting, we vented the cabin itself. I found myself sitting in there venting this thing with my gloves off and my faceplate open. It began to dawn on me that the pressure went down inside the cabin at a tremendous rate. If this thing ever stuck open and I had my gloves off and my faceplate open, I would be a dead man. So we made it a procedure to suit up when we were going to dump this thing. This meant that every 4 hours we had to put our gloves on, put our faceplates down, lock them, and get all suit up just in case this vent valve didn't reseat. Frankly, as much of an inconvenience as it turned out to be, I think that was a wise maneuver. I would never suggest that anyone vent that cabin again without being fully suited. I think there is such a risk involved that you would be fool-hardy to do it. For that reason I think that we ought to make an effort to get the ECS O_2 tank vent and the ECS O_2 tank pressure gage compatible, and at a lot higher pressure than they are. This suiting up and unsuiting every 4 hours is for the birds.

White I thoroughly agree with you, Jim. There are two things I want to know. I want to know if they deliberately lowered the venting pressure for the O_2 system down to 967 to solve the problem on GT-3. I would also like to know if they deliberately lowered the cabin venting down to 5.4. I'd like to know the answer to those two questions. I think the combination of those two situations makes what I feel is an unsatisfactory situation in our flight. It occupied far more time--

McDivitt That's right, we were screwing around with that ECS O_2. That's something we never had touched. It was a gage that we should have monitored, instead of a thing that we manipulated all the time.

White Right. Okay, the cabin pressure regulator. I didn't have any comment on that.

McDivitt Neither did I. It seemed to be doing a good job.

White I felt the cabin vent valve was set lower than I had thought it was going to be. I thought it was supposed to be set up around 5.7. I'd like to know if it was changed intentionally.

McDivitt The manual vent valve worked fine. When we wanted to vent the cabin, it vented.

White The cabin repressurization valve worked fine. I was very happy to see how well it worked also with my chest pack. Any comment on that?

McDivitt No, I don't think so. I don't think the cabin repressurized or overpressurized when we were trying to vent it. Since you were repressurizing it and venting it at the same time, I think the vent valve actually overcame the repressurization, which is a good thing if you're trying to vent it, and it is not a good thing if your're trying to keep it from venting. Going back a little farther to my other statement, in case that vent valve sticks open and you are not suited, I don't think you're going to have time to get suited. It takes me too long to put those gloves on.

White Okay, the cabin air inlet valve worked fine. We vented the cabin with it when we went EVA. It apparently worked all right when we used it down on the water. I have no further comment on that.

McDivitt Neither do I. It seemed to work fine.

White The cabin air recirculation valve worked as it was supposed to.

McDivitt As advertised.

White Okay, that primary O_2 system gets another black star. I think this is the area that I want to know the answer to,

for sure. I want to know whether that was deliberately set down into the range of the gage to solve the complaint on Gemini 3. I think that if this was the case, this is a prime example of poor engineering. As far as monitoring the system though, as long as their reading was down below 960 the system worked pretty well. I felt fairly confident that the pressure was--

McDivitt That's right. The way that the thing was set up, we could sure monitor it because we knew it was going to vent without being on the gage. I think they compromised the whole system so we could monitor it.

White As a matter of fact, we monitored it very thoroughly and spent about 100 times as much time on this system as we should have. John Young's been complaining about this point, and I think that it's a very poor thing. They ought to dig up the money and put a gage in there that will do the job. Very strong point. The quantity measuring system, I thought, was all right.

McDivitt I thought it was pretty good. I thought it was excellent as a matter of fact. It was a very readable gage. It had tremendous scale on it, but, shoot, you could read the thing to a percent. I don't know why it was any more readable than the other ones, but I thought it was pretty good.

White The flow rates--I don't have any particular comment on that. I thought the flow rate on that repress valve into my suit was satisfactory to keep me in a pressurized state and keep me ventilated enough under normal operations. Under tough operations though, the flow rate's too low, and you really heat up.

McDivitt Yes, I think since it was an open loop system, you had to keep from dumping all the oxygen overboard, and had to go high enough to keep it from dying from the heat. I think it was a compromise system.

White I thought it was well set up. I have no complaints there. Primary O_2 temperature--I don't have any comment on that.

McDivitt No, neither did I.

White The manual heater--I think that you used the manual heater twice during EVA.

McDivitt Twice during EVA for about 5 to 6 minutes each time. It responded all right, but it didn't go overboard. It got the temperature right back up there, and I shut the thing off again.

White We were able to turn the automatic part of it off quite early in the flight, particularly since this was the problem we were having. We were getting--

McDivitt That was something I wondered about. You know, the thing is marked, and we were always instructed that when the thing got down below 38 percent we didn't need the heaters any more. We shut the heaters off at 42 percent.

White Right.

McDivitt Obviously, the guy that told us to shut the heaters off at 40 percent knew what he was talking about because we never needed them again.

White I think, again, I am very suspicious of McDonnell on the fix on that gage, and on setting that pressure on 970, and I'm going to get to the bottom of it.

McDivitt Yes, but I think, though, that the pressure would have still built up even if we had the relief set at 1050 or so. It would have still built up.

White It might have built up and stabilized, because it's a cryogenic system and it could have stabilized out around 1000 or 1050.

McDivitt But on the other hand it could have continued to build right on up.

White Sure it could.

McDivitt But I sort of suspect that the--well, I don't know. It's different from this other problem where we were told that the thing didn't require heaters below 38 percent, and we found out that it really didn't require them below 42 percent.

White We turned them off at 42 percent.

McDivitt Right.

White The secondary O_2 system-- I thought those performed admirably. In fact, they had more oxygen in them than I thought they could hold. Jim's was up to around 5500 pounds shortly after launch. It remained up there and drizzled out about 100 pounds throughout the flight.

McDivitt Actually they increased by 100 psi each, right after launch.

White Right at the first mode of flight. Then they drizzled back down and stayed at 5400, I think, right on down through the flight. The lowest mine got was about 5250, maybe.

McDivitt Did you notice by chance what they were at landing?

White No, I didn't check them.

McDivitt Neither did I.

White That was the last thing I had on my mind, to tell the truth. I thought the quantity measuring was fine. It was a little questionable, that we might have overpressurized on your system, but I guess they had plenty of margin in that respect. The secondary O_2 flow rates were satisfactory as far as I was concerned.

McDivitt I think so. I was amazed that secondary O_2 flow was such that I really didn't get too hot in it.

White Yes, I was not as uncomfortable as I had been at other times.

McDivitt You know, after a while you hit yourself in the head so long that it finally stops hurting.

White It's like that big heavy suit, after a while you begin to feel good. I know the average guy on the street probably wouldn't like the flow rate, but it didn't seem to be too bad. It wasn't too objectionable. ....

White I think we jumped into something else. We were in secondary O_2 system, and we weren't on flow rate. The only time we had the flow rate on that was during reentry. The flow rate there was satisfactory. The pressure obviously was satisfactory, but we didn't check it at the end. The control-- we put an extra detent on that control. I think the control was a positive one, and we were able to keep it in the detents where we wanted it. I had no problem there.

McDivitt Right, I think that the way it's rigged up now is excellent. We designed it. It had better be, ha, ha!

White Right. Okay, the CO_2 partial pressure. The gage has been discussed prior to this time. It stayed down satisfactorily.

McDivitt Yes, it never got off zero.

White Okay, the coolant--the radiator operation configuration--I don't have the times in front of me right now that we went onto the radiator, but I think it was about 40 minutes.

McDivitt 40 minutes.

White We went on the radiator about 40 minutes, and we never had to come off it again. We didn't get any abnormal operation of the radiator at any time. One time they called up to me and mentioned something about the radiator and the coolant loop, and I didn't get any clarification. I lost contact at that time, and I thought just maybe that I had a failure of some type in my primary cooling system. So just for caution's sake, I turned on the secondary coolant pump and waited till I got contact with them again. They asked me why I had the secondary pump on, and I said, "I thought maybe I had a problem in the primary system." They asked me why I thought that, and I said, "I thought they were telling me something about it when I lost contact with them. I did it just to be sure." But that was the only time that I thought we even might have had a problem in it, and I turned it off. We used double coolant loop early in the mission, and after we turned the secondary system off we did not use it again until the reentry. Prior to the reentry, we turned it on.

McDivitt That's right. That coolant system really worked.

White Okay, here is one at which we'll get at them--the water management system. I think you have a few thousand words you'd like to say about launch. I think you actually already hit on most of them, anyhow.

McDivitt Man, I sure do. The Normal Mode, Drink Mode, and Flush Mode. We got the water management thing kind of goofed up. Let's just take the drinking thing first. The drinking nozzle was attached to the management panel by a hose, and the hose looked like it was made out of rotten rubber. The first time I tried to drink out of it, I stuck the thing into my mouth--

White The first bad moment of the flight.

McDivitt --I pushed the button in and no water came out, and I almost had a heart attack. I said to Ed, "Ed, this is going to be the shortest 4-day flight in history." Ha. Ha!

White Jim said, "Guess what? The water doesn't work."

McDivitt Ha, ha! But you'd already had a drink out of it, though, hadn't you?

White No, I hadn't.

McDivitt Oh, hadn't you?

White You handed it to me.

McDivitt Oh, so I handed it over to him, and then he took a drink out of it and didn't have any problem at all. What happened was the hose was wound in the helix. It came out to the gun in a straight line. When I drank out of it on my side, this thing always crimped like it was an old rotten piece of rubber that had been bent over in that position many times before. It looked like something that came out of a 1890 steamboat or something, instead of a--

White It looks like your old oxygen mask hose.

McDivitt That's right. It looks like my old rotten oxygen mask hose. So I think that we ought to get at least a decent piece of hose in there. The next thing is the water gun that you drink from. You push the button in, and a little spigot would come out, and the water would start running out of it. This worked great. You could always get the water to come out when you didn't have your hose bent. It got worse, and worse, and worse, and worse, and worse. As far as returning it towards the end of the flight, I almost drowned a couple of times because I'd get that thing out, and I couldn't get it back in. I finally ended up actually using two hands to operate the water gun so that I could get the button back out.

White The button definitely did get more friction in it as the flight progressed.

McDivitt It seemed like it was all scored up, and it kept getting worse, and worse, and worse, as the flight went on. This could have been a major disaster too. If we had that gun

squirting water inside the spacecraft, you'd have had water all over the place. I'll be the first to say that we made a real effort to keep the water out of the spacecraft. We wanted to get 4 days out of the flight. I felt one of the major problems would be the humidity in the spacecraft. As it turned out, it wasn't a problem. We didn't know it right off the bat, and we were really concerned about the water. The last thing I wanted to do was to have an open water nozzle running into the spacecraft. So I think that takes care of that. I think the whole water management panel ought to be clarified before we fly GT-5. We were arguing about what position the Waste Management Switch was going to be in during the countdown to launch. I think this is certainly not the time to be deciding what the heck the position these switches were going to be in. We were always briefed that this thing would be in OFF. We were going through the switch positions, and they'd ask me to check in the count at about T-45 minutes or so.

White And I couldn't see that one.

McDivitt You couldn't see that one, and you asked me to look down at it. I saw the thing was in EVAPORATOR, so I questioned the STC. He checked around, and they had a big flap about what position it was supposed to be in. Pretty soon we got a call back, and he said if I could get unstrapped and reach the thing, I ought to turn it over to OVERBOARD. We thought it should have been in OFF. They had it in EVAPORATOR, so we finally decided we ought to go to OVERBOARD to keep the thing venting. I was already strapped in the spacecraft. I undid my shoulder harness and reached around in the spacecraft and flipped a little valve over to OVERBOARD where it should be and then got strapped.

White You sure they didn't have you put it OFF?

McDivitt No, we went to OVERBOARD.

White I remember they argued. I thought they had it on EVAPORATOR first.

McDivitt It went from EVAPORATOR--

White That seems like the least likely of any position to put it in.

McDivitt That's right. We went from EVAPORATOR over to OVERBOARD. So I think a comment that I'd like to make right now about the

whole water management panel is that it's a simple thing. It's got three knobs, and each knob's only got three or four positions. We had the ECS engineers at McDonnell give us a briefing on this simple water management panel. We had about seven guys there with seven different versions of how it was designed, how it operated, and what the different positions we were supposed to be in. They got us so screwed up that when we left there, we didn't have any idea in the world what it was supposed to do.

White I think those designers didn't either.

McDivitt They didn't either, and it was pretty obvious that they didn't. We went through a lot of discussion with that water management panel. Finally I think that the four of us got it pretty well squared away. Then just before launch we found out down at the Cape that because they had gotten those switches in the wrong position, we pumped 32 pounds of water out of the adapter, used up all the pressurant for the water system, and pumped all the water into the lithium hydroxide canister. If it hadn't been for one last minute check in the data, we would have lost the lithium hydroxide canister full of water and nothing to drink with. So we would have had about an hour flight, if we had gone that long. I think that before we fly another flight we ought to have all the people at McDonnell and NASA, who are responsible for this thing get it squared away, and figure out just where the heck they want these switch positions, and get them there. If there are a lot of switch positions on that panel that aren't useful anymore, we should just go ahead and block them off. We decided between the four of us that there were--I don't even know what they call those switches--

White Condensate Valve and Water Valve.

McDivitt --and the Water Valve should be put in NORMAL and left there. That was exactly what we did, and we knew how to work the waste management valve. We didn't screw it up, but I'm not sure that if with a little trying, we couldn't have. We never had to use the Evaporator Fill Mode. The Flush Mode, or the waste management portion of the thing, had a couple of different positions. In the normal OVERBOARD position, and in using the Preheat and Flush switch over on the side, we managed to dump a large number of urine dumps through this. We dumped both our launch-day urine bags which were full. I probably urinated eight or ten times, and you probably about five or six times.

White About five times.

McDivitt About five times. So we had a lot of dumps through this thing. At 92 hours it stopped working. Ed had filled up the bellows pretty well just before this. I was the man in charge of dumping urines, it seemed like.

White The Urine Dumper!!!

McDivitt I was the only one who could reach the knobs and switches. It generally went down in spurts. About halfway through the dump, it started slowing down. Then it just went in very slowly the last two or three inches. Then I urinated in the thing and had a bellows full of a mixture of air and urine. It started dumping. It looked like it went down about halfway, and then it stopped. I wouldn't be a bit surprised if it wasn't the air going out of it. It went very slowly for just a short time, and then it stopped completely. Nothing else would go out of it. So, I turned off the Flush Switch, and I went from OVERBOARD to EVAPORATOR, and it flushed through the evaporator. We had one more urine dump through the evaporator, and this worked all right. Well, I'm sure glad that we had those two ways of working it. All the way through the flight after I'd dumped the urine through this thing, I kept saying, "Well, McDonnell finally designed this thing so it works after about 30 or 40 attempts and redesigns." But I guess I was over-optimistic because it did drop out just before the flight. It finally got to work for 88 hours. We didn't use the Evaporator Film Mode. Okay, Ed, why don't you take over. I extended my wrath.

White I just had a feeling you wanted to say something about that, Jim. Ha, ha!

McDivitt After having messed around with that thing for 96 hours trying to make it work.

White I think you expressed my feeling too.

McDivitt Did I leave anything out?

White No, no. I had the same feelings. I thought you might have had them a little stronger since you were the one who discovered the water gun was not working.

McDivitt I'm really serious about that simple panel being able to screw up the whole flight. If we don't get that thing figured out, we ought to stop flying space missions.

White One of the worst moments of the prelaunch down there was when I found out they had that 2 gallons of water in the system somewhere and didn't know where it was.

McDivitt That's right.

White The humidity sensor--I thought if the readings are right, it worked very well and proved the point that the humidity in the spacecraft is relatively low, and that the water problem is not quite the problem we had it cracked up to be. I'll make a comment on the sponge material on the side of the spacecraft at this point, since we're talking about humidity. I didn't think the sponge material was a very good idea to begin with but once it was in there, and we flew with it, I think it was--

McDivitt It was a real bad mistake! Ha, ha!

White No, I thought it was all right in there. The only thing wrong with it was what they had it treated with for fire-proofing. I thought that part of it was unpardonable. There is no excuse whatsoever for having those ammonia vapors and the hydrogen sulfate, or whatever those other things were that we had permeating around the spacecraft.

McDivitt We smelled bad enough, but it was no contest when it came to comparing ourselves with the spacecraft. It smelled worse.

White If there was any moisture, it grabbed it all. I don't really think there was any moisture for it to grab.

McDivitt I don't think so either, Ed. I kept feeling that thing, and it was dry as could be.

White There was no moisture that I could notice. The sponge stuff on the side wasn't objectionable to me, but the odor that obviously came from it was very, very objectionable. The readings we obtained, I thought, were easy to take. The stowage of the unit was not a problem. It was easily stowed in the spacecraft while we were using it.

8.5 Communications

White Okay, I have a few comments on the communications which we ought to go on to. We'll take them in sequence.

McDivitt Okay, why don't you go along, I'll express my comments.

White I think the interphones worked pretty well. I noticed one thing, though, as we progressed along. The volume requirement on both my side and on Jim's side needed to be increased all the time to get--

McDivitt No, Ed. I launch with all my volumes full up.

White Is that right? Anyhow, in my interphone I progressively raised it as the flight went on.

McDivitt Yes, I started off with mine almost all the way up. On the UHF it was absolutely all the way up, and I flew with it almost the whole flight.

White I don't think it was all the way up. The one thing though-- I think the interphone operation and quality were quite good.

McDivitt Yes, I thought so too.

White We were ready to communicate back and forth. It was just the way I would like to have done it. I thought it was very good. The UH performance at the countdown was satisfactory, and just after we got into orbit we felt that we had a bit of a communication loss. We switched to UHF No. 2. Later during the flight, we used both UHF sets and didn't have any difference in performance from either one. During the recovery you were using the UHF primarily. I think you had as much communication as you could expect.

McDivitt That's right. I think so too. I do think, though, that we had a very bad UHF situation in the first eight or nine orbits. It was really lousy. As a matter of fact, I was getting concerned that maybe we were going to have to land because we were going to run out of communications.

White You were actually working more on this problem than I was. You were communicating during the EVA work, and also after I went to sleep. I heard you working on the Communications Check, and that's when you went to the reentry antenna.

McDivitt That's right, when we ran through these checks, it finally became apparent to everyone that the reentry antenna was doing a better job than the adapter antenna. And then later on, I switched back to the adapter antenna for some reason which I can't remember right now. We ran a couple of more checks and it seemed to be--

White I know what we did. We ran an HF check, Jim, and we switched back to the adapter so we could use the HF antenna back there. We got just as good UHF transmissions at this time as we did on the reentry antenna.

McDivitt When they checked them out again, they said they still thought the stub antenna was better. So, we went back to reentry antenna.

White We used reentry just about 99 percent of the flight.

McDivitt That's right. In the last 99 orbits it was great. In the first eight it was lousy. I was really concerned about having to come down because we didn't have any radios.

White One thing that I'd like to say is, I would give a good gold star to the controllers down there. I thought their voice procedures were excellent, and their methods for giving us information were all good. I had no comment, whatsoever, other than I thought it was all very good.

McDivitt That's right.

White I had no objection. I thought there was no time in the flight in which we got a cluttered voice from anybody. Yes, I think that is pretty good when you have that many people working the loop.

McDivitt I think so too.

White Okay, the voice tape recorder--let me vent my wrath on this one.

McDivitt Get'em Ed, get'em!

White Right. This is another thing that should be fixed before the next flight. I think we're going to end up being very, very sorry. We're going to end up losing valuable data from time to time. This will be due to no reason other than a voice tape recorder which is poor on all accounts.

McDivitt We've already lost some very valuable data from this flight. We could have taped the entire EVA and brought those communications back down. As it was, we couldn't tape them because we had to put the thing in UHF so that we could transmit to the ground. We lost all of the blessed stuff going to the ground anyway.

White There are certain systems in here that I think are very poorly designed. I think this is about the poorest of them all. It's located in such a position that you can not see the operation light when it is on. The light is in an area where you normally would put things. Things get put on top of it so that if you look down there, you can't see the light. The light is such a small insignificant thing when it comes on. Unless you consciously bend your head down and look down below your right elbow, you cannot see whether the light is on, or not. The switch is set so that you have to go in either RECORD, UHF, HF, or INTERCOM, and you can not be in RECORD while you're on UHF or INTERCOM. This is a very unsatisfactory method of having a tape recorder. The tape recorder should be set up so that it can record conversations on normal UHF, HF, and INTERCOM type operations. As Jim pointed out, in our flight alone, I think we lost sets of valuable information. During launch we weren't able to tape anything onboard. We weren't able to tape the work during EVA. We could have taped some of the work during the rendezvous part of the flight. I don't believe we taped it though. The way it's set up, you wouldn't leave it on in that manner. We both had requirements to communicate over UHF. This was our normal mode of operation. If we have a tape recorder, it should have a separate switch. If there is an hour limitation on the tape, there should be a light that comes on and is easily visible on the front somewhere.

McDivitt That's right. It ought to go right on the VCC.

White That's right. That's really where the light belongs. I think that it would be desirable and important to have a voice tape of what's going on throughout the flight. I wouldn't have any objection to having a tape recorder with the capability of recording more than the 1 hour at a time that we have now. I'd like to see us recording a great deal of the flight. It'd be nice to have a switch to turn it off from time to time, if you did want to discuss something that you didn't want to go on tape.

McDivitt I don't think we ought to put the whole flight on tape. If we flew a week-long flight, it would take a week to go through the tape. You wouldn't want long periods of nothing on there. I think the way we wanted to operate it this time would have been all right, if we could have just operated it that way. There were certain periods where we put a tape on and ran it all the way through. Well, that was the tape that covered a certain experiment or something.

White On our D-9 Experiment we used it.

McDivitt Yes, that's where we used a whole tape on it. Then there were periods that were questionable when you were sleeping and I wasn't doing anything; or I was sleeping and you weren't doing anything.

White If you carried adequate tapes, and you had adequate warning when the thing went on and off, you would not have the same situation we had on the D-9 Experiment. You could have the tape stop in the middle of the experiment and be lying on your back looking out with the sextant. You haven't got any idea in the world the tape's run out on you.

McDivitt Right.

White I think that it's a very, very unsatisfactory system. It ranks right up along with the top ones, and we've already hit on some of them already. The digital command system, I thought, worked very well. I thought the light in there gave us a good indication of several things. It gave us an indication of when the station was about to come on and communicate with us. We used this as a clue to turn on our UHF to warm our transmitter up, so we would be ready when the transmission came up. I think updates from the ground came up in a very orderly fashion. I don't have any objection about that, or any further comments. Do you?

McDivitt Ed, I thought it was very good.

White Handled in a very good manner.

McDivitt I think so.

White The only update that I have an objection to is that they updated our time reference system and had it inaccurately updated by a second.

McDivitt Yes, I think there is a big flap about that.

White I'd like to find out about that, too. The real-time transmitter, delayed-time transmitter, standby transmitter--they seemed like they all worked pretty well. We had no use for the standby transmitter and we used the real-time and delayed-time transmitters throughout the flight. You don't have any comments on this, do you?

McDivitt I've got one comment. When we came over Guaymas after our computer went out, and we'd already fouled the thing up, I know, they said they wanted us to come right-side-up for a critical tape dump. So I did, and I got a message from the ground saying, "Put your Tape Playback to CONTINUOUS." So I put the Tape Playback Switch to CONTINUOUS. Pretty soon they called up and said, "Do you have your TM switch to REAL-TIME and DELAYED-TIME?" I said, "No, I don't have. You're going to have to put it down there." They didn't bother telling me that they didn't have any command capability whatsoever. I went ahead and put the Tape Playback to CONTINUOUS, which means that you're dumping all that tape. If you don't have the real-time delayed-time transmitters on, you're just dumping it into nothing. You're erasing. So we got some pretty inadequate communications there. They should have said, "We don't have any command capability. Will you please place your tape recorder and your TM switches so we can receive it?" We knew how to work the thing. It's just that the instructions we got conflicted with the normal procedures. Consequently we dumped all this tape that really was critical. I'm not sure how much of it they got on the ground. I'm not even sure if they ever got any of it on the ground, because we got some not only inadequate, but really erroneous instructions.

White Okay, communications--we covered them in coordination with the ground a little earlier. I think that the flight controllers handled our flight in a very good manner. I think that when they had something to say, they said it; and when they knew that we wanted to talk to them, they'd talk to us. When they didn't have something to say, it was kept in a good manner. I thought it was a very professional show.

McDivitt Yes, I thought that they were to be commended. As a matter of fact, when we have our worldwide network debriefing or whatever the heck we're going to have, I really intend to applaud them loud and long.

White I thought the teamwork between the spacecraft and the communicators on the ground was outstanding.

McDivitt It was really good.

White No adverse comment on any time during the flight.

McDivitt Shoot, if you wanted to talk to them, they were more than happy to talk to you. A lot of times they'd come on and say, "This is Guaymas. We have your TM solid. We don't have anything for you. If you have anything for us, we'll be standing by." And

that would be it. They were really good, I thought. We've about covered procedures.

White Right, I think we've hit that too. Okay, the communication controls and switches--voice control center--I've always been pretty happy with that.

McDivitt One other thing I want to comment on is the voice control center. If we had carried that idiotic contraption that McDonnell had designed to keep the moisture out of that thing, we would have had one more hunk of junk in the spacecraft with us. It would have been a completely useless thing because of the number of times that we switched switches on that VCC. Heck, we switched switches on the VCC more than all the other switches on the spacecraft put together. I think if we would have had to pull off that big piece of plastic every minute, it would have gone on the floor and stayed there. That's right.

White That was a very poor fix to try to solve a bad design.

McDivitt Okay, why don't you talk about that sleep configuration?

White Okay, with the sleep configuration, we knew right away we had bought a weenie. The first time I tried to go to sleep, we tried to turn everything off. We tried turning all my volumes down to zero. We turned to PUSH-TO-TALK only, and I could still sit there and hear it about a one-by-one level. It was just enough so I could hear audibly what was going on and understand if I paid attention to it.

McDivitt If you really listened, you could hear.

White That's right. If you were very close to going to sleep, and something went on that was interesting, you could hear just enough to wake you up and pull your interest to it. It made sleeping rather difficult. We didn't want to disconnect ourselves from the system altogether. We'd like to have a way to actually turn the volume all the way down and provide the astronaut that's awake the capability of controlling the voice control center's volume, so that he can turn the sleeping astronaut's volume up and talk to him anytime.

McDivitt That's right. I think what we really need in there is an ON-OFF switch for each half of the VCC.

White So you can effectively cut him off and turn him back on.

McDivitt That's right. You just reach over there, and you break the communications with a simple ON-OFF switch. Then if you've got to get to it in a hurry, you just flip the thing back on and then talk to him. I don't know where on the VCC you'd mount it.

White I think they can solve that problem pretty well. It might not be in that manner, but I think they can solve it so you've got it definitely on or off.

McDivitt That's right. They need a simple way of disconnecting the man from the communications center without disconnecting his--

White I'd say that this was a very satisfactory condition. When we finally went to get some rest, we disconnected the communications cord at the helmet. I think this is an extremely unsatisfactory mode. If we should go pressurized at any time and have to pressurize our suits, we'd just lose communications between each other. This would be a very, very unsatisfactory situation. I believe that this should be corrected prior to the next flight. The Beacon Control, Adapter and Reentry--no comment. Those were all right.

McDivitt Yes, that was excellent.

White The TM control transmitter and antenna--I don't have any comments on them.

McDivitt No, they were pretty well designed, I thought.

White That's right. Okay, the electrical system--

8.6 Electrical System

White Okay, the systems monitoring. I thought it was satisfactory. We went through and monitored the systems every time for the go-no-go checks, and quite a few times along the line in addition to this. So I thought the method of monitoring was satisfactory. I don't believe we really had any way of monitoring the electrical power remaining.

McDivitt Yes, that's a drawback, and we all know it, I guess.

White Right. That's an unsatisfactory condition and I don't know what we're going to do about it. I think it's too much of a job to try to think that you're going to sit in there and

calculate all the things you have on, and try to keep an onboard plot of what electrical power you have remaining.

McDivitt Yes, I think this is a ground function. I don't think that we can realistically do it onboard the spacecraft.

White I don't believe we got any indication of how our electrical power was going from the ground, except for one time when they called us up and told us we were 190 amp-hours - I think it was 190 amp-hours - over--

McDivitt That was after we turned the computer off. I wanted to find out why we turned the computer off and if we were really short on electrical power. Then they told me we were 160 amp-hours over the 200 amp-hours cushion. I almost went through the overhead.

White I think I'd like to have had a little more information from the ground on the status of our electrical system. The main batteries--I have a comment on them. They started out with a charge of about 24 volts and progressively decreased to the point where I was a hair concerned about them. They progressed down to the 22.5 reading and began to shade lower than that near the end of the mission. I was using the parallax to be sure I had a satisfactory reading on the gages each time. I noticed they decreased down to a minimum of 22.5. Maybe it got to 22 but it was getting near the end of the mission.

McDivitt Ha, ha! Maybe 22.49.

White Just the way I'd lean my head I could get the reading the way I wanted it. Ha, ha! The squib batteries--our electrical briefing I thought, was very good. Everything behaved just the way they told me. The squib batteries started out pretty high, around 27 or 28 volts, and they progressively decreased in voltage as we went through the mission. The main batteries--every time I checked them they always checked out at about 9 as far as the amps were concerned. The adapter batteries--I was glad we'd had the briefing on them because I realized that knees on the adapter batteries were in operation during the launch when we got a high reading on the left stack ammeter up around 27 or 28 amps, and we had a reading of around, I believe, 14 amps on the right one. I didn't alarm Jim with this information because it was still below my cut-off point of about 30 amps or so. I felt that it was due to the knees in the adapter batteries causing unequal loadings of the main batteries with respect to the adapter batteries.

McDivitt Hold it. I want to make some comments about the electrical system and the power as we used it. When we powered down, we turned off the ac power, the OAMS power, the ACME bias power, the rate gyros, the horizon scanner, the IMU, the computer, both FDI's, and the attitude indicator lights. We operated with as little in the way of cockpit lighting as we possibly could. It got less, and less, and less as the flight progressed. In earlier orbits we had all the lights on in the cockpit--the over, the middle light, and the two side lights. Then for the nighttime passes, as the flight progressed, we got around to using the red lights. We finally got around to making the nightside passes generally with one red light on or one white light on, as we got more confidence in the spacecraft. I think we save quite a bit of power that way. They were surprised that we were 160 amp-hours ahead, and I don't think that we got that way by accident.

White I've got a comment to make on that. We were both watching the loadings, and I could read them a little better over there. We started out operating around 14, maybe a little better. The reading on the combined amp-hours slowly decreased down and near the end of the mission, we were down to 12 or 13 amp-hours on unpowered down configuration. That was as low as I saw it go, down around 12.

McDivitt Another thing that we did was that when we weren't actually planning on transmitting on one of the radios, we were always putting the mode control switch to INTERCOM, which would then cut the transmitter off the line. You could actually see the ammeter go down a little bit. So I think that by really powering down the spacecraft and getting all the non-essential items off the line, we helped ourselves a lot. We got this 160 amp-hour cushion because we really worked at it, not because it just happened like that.

White This takes a little diligence.

McDivitt Yes, not because it was a miscalculation on the guys who were planning the flight, but just the fact that we really worked at keeping the lights off, keeping the radios off, and keeping those little bitty things down. You know, you only have to save two amps per hour. We ran on a single suit fan almost the entire flight, except when Ed was getting warm when he was sleeping we had to go to two suit fans.

White Right. When it got so uncomfortable that I couldn't sleep, we would go over. We really didn't do that too much.

McDivitt No, we didn't. We made a real effort to keep the electrical load down. I think that it sort of showed up there towards the end of the mission when we really had enough spare power to run the ICS through the last day--uselessly of course, but at least we ran it.

8.7 Computer

McDivitt In the launch we had the computer in ASCENT. Ed was reading out the errors during launch. I read out the rates which didn't require any information from the computer.

White I was reading out the lack of errors most of the time.

McDivitt Lack of errors, right. Why don't you discuss the error status.

White I think we discussed it earlier, and I'll just go briefly through it. We didn't have any errors that I feel would be worth repeating during Stage I. At guidance initiate we got a full-scale-down indication. This indication I had been told was fairly routine, and it appeared routine to me too, as it began to steer into zero and steered right on into zero. As we approached SECO, the error started to increase a little bit and increased out to a little less than a degree in pitch-down on the error needle. Aside from that, we didn't have, as far as I can see, any other error that was worth talking about during launch.

McDivitt Okay, at SECO+20 the IVI's counted up as we separated, rolled around, and did all the maneuvers we were supposed to. The IVI's acted as they should. When I got turned around and was faced toward the spacecraft, I was in a hurry to get all these things done. I started thrusting, and I went from Ascent to Catch-Up, and then hit the Start Comp button. I lost a couple of ft/sec here, but this was sort of insignificant at the time. The IVI's counted up in the Catch-Up Mode and they operated properly throughout the rest of the chase phase of the mission. We were getting the kind of information that we needed right there early in the flight. Ed had 52 punched in, and it read out at 30 ft/sec, I think he said earlier.

White Yes, I picked that up later on because I wasn't even concerned with it, since we had a good orbit.

McDivitt Once we had a good orbit, that kind of information wasn't that important.

White Do you want the IVI readings at this time?

McDivitt Yes, you might just as well read them out.

White The IVI readings at the time we decided to read them--at zero, zero, zero on the attitude indicator--20 forward, right 11, down 5.

McDivitt The attitudes weren't really what they should have been, because we had a good insertion, and we had to go right then, and we had to get turned around and get at that booster. I didn't fool around with getting the spacecraft at exactly the right attitude to read out the IVI's. I thought that was of academic interest. It would be great for post-flight analysis but it wasn't going to help the flight at all. So I didn't do justice to those things. I'm sure that we can go back and resurrect this thing to find out exactly what it was. It wasn't very meaningful at the time. The orbit maneuvers consisted of really just chasing the booster around and reading up the IVI's as they came out. We received all our updates properly. We got the computer on and got it loaded. The DCS updates were going in, and they were getting verification on the ground. One time I remember we didn't get the DCS light. As a matter of fact, they sent the load up again, and we still didn't get the DCS light. They verified on the ground that it was going in.

White Well, the funny thing was when the computer wasn't on we got a DCS light.

McDivitt The DCS lights came on when they get set up for the TX and send out a real time command, too.

White Well, maybe the TX when they sent up--they kept telling us that they got a good load in it and I had no light. I really didn't quite believe them.

McDivitt Neither did I. As a matter of fact, we had it verified at the next station.

White Okay.

McDivitt And that's where the onboard computer thing ends. I might go through what happened to the thing. We were over the States and had the onboard computer on for getting a new load in it. I got just about over Florida. He said, okay, I could turn the computer off. I turned the switches off and nothing

happened. The comp light stayed on, and I don't even think the malfunction light came on, did it? No, it didn't. So I said, "Well, that's interesting that the darn thing doesn't go off." So we flicked the IGS power off and back on quickly and told them on the ground that it didn't look like I could get the computer to go off and stay off.

White I think you told them you thought you had a failure in the switch.

McDivitt Yes, I told them it looked to me like I probably had a failure in the ON-OFF switch or the ON-OFF switching function. And they said okay. So I said, "What do you want me to do here?" I knew we could always turn it OFF by turning the IGS OFF, but I wasn't too keen on that. So they said, "Stand by. We're going to have the experts check it." So we flew on out of communication with them. I think they talked to me over Bermuda too, but nothing of much importance. They said to stand by they were still checking it. Then we got over Tananarive and I got this message to turn the switch to the ON position but to turn the ac power to ACME, which was going to power down the computer whether we wanted it to or not. It was a voice relay station but we weren't getting the voice relayed. We were just getting a message sent up from somebody on the ground. I'm quite sure we didn't have any controllers at Tananarive. I don't really know who was talking to me. Probably some COM TECH. So, not being able to discuss the thing with them and not knowing what the status of my total electrical power was at the time, I went ahead and turned them off. The comp light or the malfunction light came on, and then it sort of got dim and went out. Then I sort of figured, that's the end of the ACPU. So we put the thing back on over Carnarvon and back off again, and it wouldn't come on. It was dead, of course. So that's the life story of the computer. Then we played a lot of games afterward, trying to make a dead man come back to life. I have nothing else on the computer. I sure wished I'd have had it though.

8.8 Crew Station

McDivitt Controls and displays--okay, I'll talk about that. The sequential telelights all operated properly--came on in the proper colors, and punched off and everything. The event timer operated properly. The IVI operated properly. The flight director indicator operated properly. I would like to discuss the GLV fuel and oxidizer pressure gages here for a

minute. We got about a $25 million vehicle, I think, that depends almost entirely on a launch. We've got an onboard manual detection system, or something like that.

White Malfunction detection system.

McDivitt Malfunction detection system. An integral part of the malfunction detection system, is the fuel and oxidizer pressure gages, for both the first and second stages. This is one of the abort criteria. On the scale of these gages down below the glass is a beautiful, beautiful set of lines and numbers and hash marks that are wrong. They updated the GLV information and found out that these things were in error by quite a bit. Now, to take and fix these gages would have taken a couple thousand bucks. I don't know exactly how much or how long, but would have taken a few dollars. Instead we decided it would be simpler, cheaper, and a lot quicker to go ahead and paste some paper decals over the top of the glass. The parallax with these things is horrendous. The decals were pasted on over the top of the glass in such a manner that they completely obscure the inside-the-glass readings. They also obscure the center needles which are not only the clue to what the tank pressures are, but a clue to whether you have any APS power, which is also critical. When you cut these things back so that you can see the inside needles, you see the inside gage too. I think this nickel-dime fix to our multimillion dollar vehicle is ridiculous. I think that we ought to get those inside gages painted the way that they're supposed to be painted. I think we ought to end this Mickey Mouse gage routine right now and get going on GT-5's fuel and oxidizer gages for both stages. It's ridiculous the way they are right now. The altimeter worked as advertised. I mentioned that it went down and back up again at around 100 000 feet. The rate of descent seemed to be all right. The accelerometer was okay. The switches and circuit breaker panels--I had no comment. We knocked a couple of switches and circuit breakers off during the course of the flight. We always caught them and got them back on quickly, or maybe we didn't get them back on quickly. We got them back on quickly enough because nobody ever said much to us about it. They commented one time. Two times, I think, they asked us if we turned something on or off.

White I remember that. One was over on my side.

McDivitt Was one the A pump on the secondary loop, or the B pump on the secondary loop, or did you turn that on?

White No. I think one of them was up there, and I forget how we got it on.

McDivitt Maybe we just bumped it. Yes, there was another one over on your right-hand side and there were a couple of them in the center circuit breaker panel. One time I know I bumped one on the left-hand side circuit breaker panel. I thought it was the electronic timer. It was one right above that. I almost had a heart attack when I saw that thing go down because it would have messed up the whole time reference system. I thought the switches and circuit breaker panels were very good. I have no complaint about it. I think that's a well designed cockpit. The mirrors were fine, and the swizzle stick was a real life saver. I can't reach the circuit breakers and switches over on the right-hand side unless I use the swizzle stick. I had to do a lot of switching when Ed was sleeping. This swizzle stick was the real answer.

White I've been always telling you to get some long arms. Ha, ha! I didn't use the swizzle stick very much.

McDivitt Yes, but you don't have to reach over and get those switches all on the left-hand side.

White I found the swizzle stick was quite useful for unstowing items out of the center stowage box.

McDivitt That's right.

White It was really good there. I used that every time when I unstowed.

McDivitt It's a good piece of equipment. Okay, lighting--do you want to cover the lighting, Ed?

White Okay, I think that the lighting, to me, was surprisingly good. I think that at one time there was apress to put two white lights on either side on the instrument panel. I think the lights on the instrument panel should remain just as they are. I think we used the red light much more than we used the white light. There was quite a bit of time when you had to do a lot of out-the-window operation at night and you wanted to have some reference inside. The red light doesn't seem to destroy your night reference at all. So I think the instrument lights, the two on either side above the panel, are satisfactory. I also thought the deletion of the red light in the cabin light and the substitution of a bright white light was certainly good. There were several times

when I wanted to get a reading on something right away, and I didn't want to fool around with dim lighting. I would switch on the big bright light and I was almost always able to get good readings. Now when the sun was really bright in your face, there was a period of time in which your eyes had to adjust to the instrument panel before you could make the readings. I think you could put spot lights in there and not get by that problem.

McDivitt That's exactly what I was going to say. Lights aren't going to solve that problem.

White No, it's just plain bright outside. When you look back in, even though you have your lights on, it's fairly dark inside. I personally wasn't troubled by this very many times during the flight. Were you, Jim?

McDivitt No, I wasn't.

White I didn't feel that was too bad. So, actually, I felt that the lighting, although not abundant, was adequate. I think the actual lighting of the instruments would certainly be nicer if we had individual instruments lit up. Oh, one thing--several times I would like to have had a flashlight in there, something where I could direct a real beam of light. The little side lights, I thought, were close to being useless. I didn't use my little side light, the auxiliary light, very much at all.

McDivitt As a matter of fact, I didn't either.

White Very seldom. I think that if we're going to have a little auxiliary light like that, it ought to be a light--

McDivitt It ought to be a big auxiliary light! Ha, ha!

White -- a directed beam. This goes right back to something that we forgot to point out in water management. I think we ought to point it out right now loud and clear. I think that we have to have a system in which we can gage the water outflow. I think the medical people feel fairly strong about this also. I know that I restrained from drinking because I didn't want to drink all the water out of there prior to the end of the 4 days. I got a feeling Jim was doing the same thing.

McDivitt That's right. I was doing exactly the same thing.

White I didn't drink abundantly at any time during the flight except perhaps right before the reentry. I felt I was taking quite a bit of moisture with my reconstituted food. I felt that if I overdid it the first part of the flight, we wouldn't get through the last part, because water is so critical.

McDivitt That's right. We've got a number of expendables like OAMS, and we've got a couple of gages for the propellants. We've got the ECS oxygen. We've got quantity gages for that. We've got electrical power, and we've got ways of measuring that from the ammeter. We've got food, and we can always count that. But when we get down to water, which is just as critical as all these other things in flying long duration mission, there's not a single way in the world we can measure how much we've got or how much we've drunk. I think it's imperative that we get some method of measuring this thing before we try to fly another long duration flight.

White The white light on the little utility light was not satisfactory. We tried to look to see if we could find out what we had in the cabin bottle--

McDivitt Water tank.

White And that wasn't satisfactory. I think we ought to have some type of a metering system which would enable us to actually determine the water that we've utilized, and in some way know that we're getting it out of the adapter. I don't know. We need to look into the whole water metering system, which is non-existent, and see if we can't get some kind of system.

McDivitt You know even if we can't get something that they can pipe into the spacecraft, at the very least we ought to TM the pressurant pressure down to the ground and back up again, or something, and get some sort of calibration curve--

White So that we'd know what we have remaining in the adapter.

McDivitt We could at least call the people down at the ground and say, "How much water do we have left?"

White That's right. And I think we ought to be able to tell what our bottle has inside of it in the spacecraft.

McDivitt Yes, I think they're really two separate things. I think first of all you've got to know the total water that you've got left and the rate that it's going down. I think the second thing that Ed's pointing out is that we don't even

have any way of telling what the water supply is in the spacecraft. The first clue that you get that you're out of water is you just run out of water.

White The lighting on the water management panel I think is just about non-existent. You can see it in the daytime. If you know the position of the switches and know where they're supposed to be, you can make sure they're located properly and on the proper indication, but I can't read anything down in that area at night. The lighting is very poor in that area.

McDivitt One think that I'd like to comment on here, a little bit, is that amber light that I insisted that they put on the Preheat-Flush switch over back of the water management panel. I felt it came in real handy. Two times during the course of the flight I left the Preheat switch on after I flushed it for short periods of time to make sure we didn't have any ice left in the lines. I did it on every occasion, but two times the thing that called my attention to the fact that I still had the thing on, was the fact I could see that orange light--amber light--shining up between the food box and the front of the spacecraft. I could tell that I had another light on in the back.

White And so I think the left panel, center panel, right panel, pedestal, and console are not lit abundantly, but are lit what I'd call adequately, and perhaps a little marginal in some cases. I had no difficulty in reading the designations on the switch-breaker panels. I think they were lighted adequately also. I'm not going to say they're lighted well, because I don't think the lighting is real good in the spacecraft. The water management panel isn't lighted properly. I'm not sure we really have to have it lighted too well. The utility light, I think, as they are now, are very close to being useless. It's like taking a match and trying to use it to find your way around. It doesn't provide enough light. From time to time I would have liked to have had a light which had a little stronger output of light available, so that I could--I several times wanted to look behind my seat for things at night, and I'd like to look down into the area in the water management panel light.

McDivitt Yes, I think probably the wattage on those bulbs should go up in order of magnitude to make them effective.

White You use it so seldom that it wouldn't be a big power use. You'd only use it when you needed it. It wouldn't be something you'd use very often.

McDivitt I'll tell you what it all is, though. When you want it, you want something that you can see. You just can't see with those things at all.

White I don't particularly understand what the interior and exterior lights mean. Do you?

McDivitt I think the exterior lighting is probably the lighting that could probably be used for docking. We didn't have any exterior lights.

White I thought the intensity control of the lights was an absolute necessity, and I think it was satisfactory. I think the fingertip lights are quite useful, and were commented on already. They should have the Lexan covers, and we've also commented that they should be located between the fingertip and the first joint. The onboard data--now here we come to a very useful piece of equipment. Ha, ha! I believe I made a considerate effort three times to update that thing, and I never got up with it any one of those times.

McDivitt We had three positions on our flight plan strip. We had launch, the first 5 minutes--the next time I tried to get it was 25 hours. The next position was 88. Ha, ha!

White And neither time did I catch up really where we were. I turned, and turned, and turned, and then got distracted into something else.

McDivitt Quite frankly, the only things I ever saw in that flight plan roller were the 25-hour and the 88-hour times, and I never even read what it said.

White I didn't quite agree with--

McDivitt 84 it was, I'm sorry. It wasn't 88, it was 84. And Ed wrote something on here. He wrote my parachute-deploy time.

White I wrote your times during reentry on there.

McDivitt It would have been much more useful if there hadn't been anything on it at all.

White Yes, we put a few times up there--

McDivitt I couldn't read those things, which were the only numbers that I really was interested in at all.

White 400K - 2+38 - Chute 12+33 - The only two that I thought you really needed were those two. I put them on there. I didn't thoroughly believe Gus when he said you ought to take the thing out, throw it away, and leave a hole in the instrument panel. But I'm inclined to agree with him right now. You ought to take it out, throw it away, and leave a hole in the instrument panel. But honestly, what I do think ought to go up there, is a good digital clock readout.

McDivitt I don't think an analog clock in that position would do you any good though.

White They both have a high degree of parallax.

McDivitt Yes, the parallax would make it useless. I think if it goes in there, it ought to be digital.

White Yes, a 1-second clock.

McDivitt I'm not really sure that we're going to get a digital clock in because of the complexity and the weight, and all that jazz.

White Let's talk about the clocks right now, Jim.

McDivitt Okay, let's talk about the clocks.

White I'll hit mine, and then you hit your, and then there should be a conclusion that we could come to.

McDivitt Very good.

White I think the clock on my side is unsatisfactory. I wouldn't recommend flying it on another flight. It's difficult to read. There are two hands going around, keeping track of minutes, and sometime you read the wrong minute hand. The one that's keeping your hack--it's easy to mistake for your minute hand. The way the face is marked it's difficult to read the minutes out. The hours interfere with each other. The whole readability of the clock is unsatisfactory, and the readability of the hands is unsatisfactory. So, I think the clock is out in all counts as far as I'm concerned. I

kept watching Jim's clock over there, and I think I could get a better Greenwich mean time off of his clock than I could on mine on my side of the instrument panel.

McDivitt Hey, let me comment on mine. I thought the readability of that Accutron 24-hour clock was excellent. The accuracy of it was lousy. It lost 4 or 5 seconds every day or more. I reset it about every 24 hours. My Omega wrist watch that I had set on G.m.t. never lost a second, except I forgot to wind it one day, and it ran down. It stopped. Ha. ha!

White I was guilty of the same thing.

McDivitt But the Accutron clock on my side of the instrument panel, that they put on as sort of an afterthought, was indeed a fine clock as far as readability. It didn't have any chronometer function to it at all. It had strictly a second, minute, and hour hand on it. It told you G.m.t. and it didn't tell you anything else. It told you G.m.t. in a way you could read it. You could read out the minutes, you could read out the hours, and you could read out the seconds. I really didn't have any trouble with it at all. It had a nice thin second hand which I find to be much more useful than those great big blunt things with huge arrows on the end of them. I hate to lose the chronometer feature on that right-hand side, but I do think that the readability of this thing, as far as the G.m.t. is concerned, is so much superior to that other clock, that it isn't even comparable.

White I'm not sure that the chronometer function on that side is really too important.

McDivitt Don't you?

White No, I would be perfectly happy to go ahead and take that out and put a good clock on there in Greenwich mean time. Now I've got some further comments on--

McDivitt I guess what you end up with is two clocks that aren't any good. Neither one of them is any good. You'd rather end up with one clock that was good.

White Yes, the way it's combined together right now, it's really not too good. I hacked your OAMS burn on my watch. I work with two clocks on my left arm, and it worked out real well for me. I had elapsed time on one, and I had Greenwich mean time on the other. I used the elapsed timer as the one on which I made my hacks. So I feel we got adequate backup.

If one poops out, you can use the other one to make your time on. So, I think we should have a good clock to keep track of the time in the spacecraft on the instrument panel. Now, I'd like to get back on the clocks again. I think that elapsed time is the only kind of time that we ought to have in the spacecraft. I think that we ought to have a good method of keeping track of elapsed time. I think probably a 10-hour clock that keeps track of each 10-hour increment that you pass to a high degree of accuracy, is the kind of clock that we need. I don't know what we're going to do about wrist watches. Maybe they'll design us a 10-hour wrist watch that we can wear. I don't see any reason why they can't. They can design 12-hour ones just as easily. We're going to go this in Apollo. We should face up to it and go ahead and spend the money to get ourselves a proper timing piece of equipment, and get our ranges and stuff operating on elapsed time. In long flights this is the kind of thing that's going to be of interest. It was confusing to me, to tell you the truth, to operate on Greenwich mean time and elapsed time throughout the flight. I was constantly adding and subtracting. They'd call us up Greenwich mean times and I'd want to convert them to what I was using on my flight plan. I found this a great inconvenience.

McDivitt I concur with what Ed said. I ran the whole flight plan using elapsed time except for the times where they called a specific G.m.t. to perform a function. I did it off of a 12-hour face wrist watch. I added up all my 12-hour increments and came to whatever I wanted. If I had something like 83 hours and 15 minutes, I had to figure out that that was six times around the clock, and another 11 hours, and another 15 minutes. Obviously, not the best way in the world to do it, but the only way that was practical from the standpoint of the flight plan.

White Well, to tell you the truth, Jim, I feel strong enough about that elapsed time that I would be happy to go with that type of a system of timing, and just go ahead on elapsed time all the way and use 12-hour increments. They would call up your time and elapsed time, and use your own clock to keep track of it. I felt it was simple enough also to do it in this manner. But I feel that this is inferior to having a good elapsed timer and 10-hour digital increments.

McDivitt I tell you I hate to see us get involved in something where you've got a clock that's so difficult to read, where you've got to add up twelves and--

White Now, you're on the other side of the fence now!

McDivitt No, I think that we ought to do things like retrofire time and that sort of thing in a standard time that you can use--something like G.m.t.

White Well, you really need--elapsed time. If we had elapsed time--

McDivitt If we had a good elapsed timer onboard the spacecraft, I would say that there's no doubt about it. Elapsed time.

White I think we ought to start working on it right now.

McDivitt Elapsed time is the way we should go. I don't think that with the timing systems we've got available for the Gemini that we want to go to elapsed time for the whole mission.

White Trying to get our data back from this flight is going to be a horrible mess because of those two timing systems.

McDivitt I know it. I agree. Before we launched, we knew that we wanted to run it in elapsed time, and there wasn't any doubt about it.

White I think maybe if we make the point strong enough, maybe they'll get busy on it.

McDivitt You're right. We'll get going on it.

White Okay, why don't you take the checklist cards, Jim?

McDivitt The checklist cards. We had two complete sets of cards that were broken up into two groups. We had the launch, insertion, Mode II and Mode III aborts, EVA, the suit check, and all the things that we were going to use in the first five orbits of the flight on one set of cards. We had another set of cards from Preretro checklist down to the postlanding and emergency egress. The cards included all the plots that were needed to do all the retrofire, and to make corrections to take care of all the non-nominal things that might happen to us during the retrofire. We also had in this group of cards a card that we used to contain the final retro information such as with OAMS or without OAMS burns, time to reverse bank, and all the other things that we had. It was a format, something that could be easily held in our hands and was actually used during the launch, during insertion, and during reentry. We actually had these cards out so we could check them off.

White I thought the only thing we would have out during these two critical busy periods of time were these two easy-to-hold, easy-to-operate, hand-held card checklists. The rest of the stuff was all stowed away.

McDivitt We got every checklist that was required to make the spacecraft run on these two sets of cards, which together were about $\frac{3}{4}$ of an inch thick.

White I feel that we had a real workable solution to the problem. These things were the same size as those carried on GT-3. They were much more expanded than what GT-3 had. We had the whole how-to-operate the spacecraft routine on these cards.

McDivitt The preparation and availability of them--is this from a training standpoint. That is later in the brief.

McDivitt Well, anyway, we actually received our cards at about 8:00 the night before the launch.

White That's the thing that I was hollering about the loudest not to have happen, and it happened. I understand why it happened, but--

McDivitt We had so many changes in the flight plan, and nobody was working on turning this stuff out. Our time was so filled with over-all training and the change in flight plan that we just didn't have time to go--. We did not have time to go through the checklist over and over. When we did go through them it took too long to get the thing back to us. Dick Benson came down to the Cape and did an absolutely marvelous job, I think, in getting these things turned out.

White I think he did, too. I think we all owe him a real vote of confidence.

McDivitt That's right. He did an outstanding job.

White I think the biggest confidence builder that you had, Jim, was when we started getting these books.

McDivitt That's right. Shoot, I was worried about us getting ready for the flight because I didn't think we would be able to get all this stuff together. Finally he showed up and really went through it, but it doesn't change the fact that these checklist cards and data books didn't arrive until 8:00 the night before the flight. We had a few changes that had to

be made. I guess I went to bed about 9:30. Dick Benson and Martin Miller were still in our conference room making changes in our books. So a lot of these things we didn't see until we flipped them out in flight. I think our data books, as we had them laid out, couldn't have been better. Well, I shouldn't say that; there is always room for improvement.

White Yes, I think we could organize them a little better for utility and use. We had so many changes in so many things that got put in at the end. It got so that they were put in in a bit of a helter-skelter manner, but certainly they were easy to find.

McDivitt Well, I don't know. I was really quite pleased with the outcome. I think that the general arrangement of one data book and two--whatever we ought to call those other books--

White What did we call those other books?

McDivitt Two Experiments and Spacecraft Procedures and Flight Plan Books--

White Two procedures and one data.

McDivitt Yes, two procedures books and one data book. One thing I would have changed--I would have expanded the flight plan and made maybe two or three times as many pages as we did. We could have written all the notes right in it and had enough room to make it intelligible. Because it turns out, that's where we really kept all of our notes.

White Yes.

McDivitt Right on the flight plan.

White About the way they had it initially was pretty good. Maybe that's a little more than we need, but--

McDivitt No, I don't think it is, Ed. I think that is the way it should be.

White This is a whole hour on one page.

McDivitt Really?

White Yes. So later on you see, they went from 1 hour down to 6 hours on a page. Maybe if they cut that in half and made 2 or 3 hours on a page--this is probably about the--

McDivitt Two hours on a page for our flight would have made 50 single sheets or 25 double pages. That would not have been bad.

White That probably would have been just about the right length.

McDivitt We'd have gotten a lot more out of our notes, I think, because we found ourselves scribbling in places where it was pretty hard to determine where you were.

White The requirements to make changes in the book after the flight goes on is absolutely nil. So, I think that rings should be replaced with something that doesn't come undone. My rings came undone several times during the flight, and luckily only one at a time came undone. It would have been a real mess if any of these books would have come apart, because it would have destroyed numerical sequence. So, I think something other than rings ought to be used.

McDivitt I tell you one thing I found--that size book and that concept that we had, I think, was really good.

White That was just the right size.

McDivitt It's just the right size. Their sheets are big enough where you can write a lot on them.

White They're easy to handle.

McDivitt They're small enough so they're easy to handle. They're easy to stow. They fit into the flight suit. When we launched, I had both flight sets of data cards in my right lower pocked and the big data book and my procedures book in my left-hand lower pocket. I had all the checklists right on my spacesuit.

White I had one procedure book and both my cards.

McDivitt And both your cards. So that between the two of us we had all the data books right on the flight suit, which was just right where we wanted them.

White Another thing we did--we hand carried this equipment down to the spacecraft to be sure it was there on launch.

McDivitt The maps, overlays, and star charts we should lump all together along with all the other junk that we carried in the data case.

White Let's start with the star charts. That's easy. I thought the star chart was satisfactory. I think you used the one with less stars on it than I had.

McDivitt Yes.

White I used my own one that I fly with all the time and I was quite happy with it. I think this is exactly what you need, and I don't believe you need to overlap two times around, but that wasn't for the chart.

McDivitt Yes, and really, the flight chart, the one that was actually designed for the spacecraft, was designed so that this swiveling out-the-window display fit on it. It was a certain size to take care of that and had a lot of dead space out on the edges. I would have rather seen the stars expanded more so that we could tell it. We used two polar plots of stars that were put out for the Apollo thing that we picked up on our training. We actually flew with one of the training things. I took one out of my brief case.

White Those weren't put out by Apollo. Those were put out at our request. Remember? We asked for a--

McDivitt Yes, but I thought they came from the Apollo office.

White No, they came from our own Flight Crew Support.

McDivitt I know we requested them, but I thought that's where they dug them up.

White No, they got them from--

McDivitt Okay.

White See, what they did is they added on all the Apollo navigation stars. They came from our own boys in FCSD.

McDivitt Those polar charts are really the cat's meow.

White All those charts are pretty good.

McDivitt So I thought the star charts sure gave us all the information we needed. The maps and overlays--I think we really ought to cover the maps and overlays by the experiments. The map with the sliding overlay of the orbits, I thought was a real good tool.

White Very easy, yes.

McDivitt Very easy to use, and I am sure glad we came up with that.

White I think also carrying pre-plotted orbits on the maps was also useful and stayed pretty--

McDivitt That's right. Right at the last second we decided to take four maps that were glued back-to-back so we had two sheets. They were on a sticky-back which made them reasonably thick and durable. One of them had no orbits on it, one had 1 to 22, another one had 22 to 44, and another one had 44 to 66. You could look through there, and you could get a quick reference of where you were going to be at a certain time. The times did get off, but you were only off a little bit.

White You can keep track of how far you're off.

McDivitt You knew about where you're going to be. As Ed says, as the time went on you could tell about where you're going to be just by knowing the correction. It didn't change much. So, we found these to be pretty useful. We didn't really get to start using them until the second day.

White I didn't know you had them in there.

McDivitt We took them out, I guess, one time when you were sleeping just for the heck of it and, my gosh, they started working pretty well.

White I used them almost exclusively once we got them out.

McDivitt Yes.

White We had a lot of other information onboard, and I don't know whether we should go into all that stuff now.

McDivitt Oh, yes, I took schematics of all the systems right out of the GOH. I didn't ever have to use them, but I thought it was worthwhile having them along. Everybody was getting so screwed up on the water management panel, and I took my notes on the water management panel with me. I had a couple of drawings.

McDivitt I had what happened when I put all those valves in a lot different positions. You know, when you compare something like that digital computer with the water management panel, you certainly think the computer would be more difficult to operate. But after the million conflicting descriptions we had on the water management panel, I think we all agree that it was the worst in the spacecraft.

Stowage

White Well, I guess I was the chief stower and unstower.

McDivitt All I did was take the food out.

White I thought the stowage in and out of the center stowage box was probably the easiest place to get in and out of. The boxes were easy to slide in and out, and the stuff was easy to put in and out. I felt that the right-hand wing box was tough to get in and out of. Getting in to get the bags full of equipment took a little bit of time. When I got to actually stowing the refuse back in the right hand box, it was easy enough for me just to reach over my left shoulder and put the items in without even turning around. It was pretty easy to use as a trash can. The stowage of the items of equipment in the footwell, to me, was not objectionable at all during launch and reentry. The ventilation module which was stowed on the left side of the right footwell was well out of my way during these times and offered no impairment to me whatsoever. Something that was a bit of a surprise to me was all the equipment we had in there that we were not able to jettison after EVA. I knew we were in for a bit of a problem with so much equipment. I think the stowage of the miscellaneous pieces of equipment underneath your legs, back up in the heel in back of the stirrup area, is pretty good storage for almost all of the loose items during flight. Jim and I had the area just chucked full.

McDivitt This was not any big surprise. Remember how we were talking about how we were going to put all that stuff up?

White We were going to put a big refuse bag in there.

McDivitt We decided that the most likely place to put these big items would be back underneath the seat because we weren't going to keep our legs back there. We never did get them back there.

White There was no possibility to put them back there once we filled it up.

McDivitt Yes, but even if we wanted to, I don't think there was any big desire to put them back there.

White It would have been nice to stretch but that's just about all. That would have been from time to time.

McDivitt That's right.

White I found that actually the thing that I appreciated the most was having a lower seat so I could actually stretch my legs out forward, then actually behind, and bending my knees.

McDivitt Yes, I was more interested in straightening my legs out than bending them back more.

White I couldn't have done that if they hadn't corrected that seat. I was able to get in and use the stowage in the refuse box on my side fairly easily.

White This is the rubber covered box. Jim said his wasn't quite as easy to get into. I had to get into a certain position to get back there, but it sure surprised me. I thought it would be just about useless.

McDivitt Well, I got things out of it. I got a defecation bag out one time, and I got another little bag out. I don't know what else I had back there.

White The right-hand box with the clamp lock was easy to get in and out of. I stored things from time to time in there.

White Yes, I found that the most useful storage area that I had was the right-land little velcro covered container right down by my right knee. I kept all the slides for the cameras and the miscellaneous little pieces of equipment in it. I felt that was a very useful container.

McDivitt Is that the one with the canvas cover on it?

White Yes, I really used that one.

McDivitt Yes, that was pretty nice.

White The periscope container I didn't use much at all. I really didn't need to use it. I kept the blood pressure adapter in it throughout the whole flight.

McDivitt The left-hand aft food box actually had food in it. It was pretty difficult to get the first piece out. It was a long hard struggle, but I finally got one piece out. Once I got one piece out, the rest of it was a real snap. They had the things taped together. I left the door open the whole flight after we once unstowed it. I would leave a meal floating out so that when I wanted to get a meal I would reach up and grab the meal that was floating loose. I would pull the tape out until I got a hold of the tape so I could force another meal out of the box. Then I would cut the first meal off and we'd eat it. I managed to get all the food out of the box without getting out of my seat. The left-hand side box had the film stowed in it and it was easily accessible. I think the most useful stowage place that I had in the spacecraft was the little Volkswagen-type bag that we had made up and bolted on the center pedestal.

White Oh, that was a jewel.

McDivitt We kept out checklists, maps, data books, and procedure books in it. When we went to sleep and had a change of command and we wanted to get to one of the pieces of equipment that the other guy had, we almost invariably stuck it in that little pouch. I really think the most useful thing that we had put on that spacecraft were those little pouches.

White Yes, I think the pouch could even be made a little bit bigger.

McDivitt I think it could, too.

White Then it could receive a little bigger item and perhaps have a little more volume that it could expand out to. I think that it was a very useful item. We used that as storage area more than any other.

McDivitt That's right.

White I used the long, khaki refuse bag on the side for various things, but the main thing I used it for, once we got the flight going, was a refuse can. I would put all my refuse in there until I got a full container of it. Then I would package it up and put it back in the right-hand box. I thought it was very useful.

McDivitt I used it for all kinds of things. I stored your Mae West in it, and I had some of the camera equipment in it when we were doing EVA.

McDivitt When I got all the good pieces fished out of it, I finally started putting trash in it.

White We both have an interesting item on this. Well, I emptied mine out all the way, but I think you entered with it full of trash.

McDivitt I reentered with that bag full of trash and it didn't tear off.

White It was in pretty good shape.

McDivitt It was light-weight trash. Papers and things like that.

White I have a comment on the other little trash bag. I never used it.

McDivitt Neither did I. I would get them out and I did not even know where they were. Yes, I think it's just too small.

White Yes, it's just too small, and I think that Volkswagen pouch can be improved upon. I think both right and left canvas storage bags were very adequate and should be continued. I think it's satisfactory just the way it is.

McDivitt They could make the velcro strips on it a little longer and the velcro strips attached to the spacecraft a little longer so that it didn't have the big curls on the edge. It tended to curl in and make an opening. I never could get the thing closed.

Belts

White The belts worked satisfactorily.

McDivitt Yes, mine worked very good.

Harness

McDivitt Harness. Okay.

White The harness was satisfactory.

Life Vests

McDivitt Life vests. Very good.

White Very good.

McDivitt I might comment on those life vest. I never took my life vest off my restraint harness the whole time. It wasn't in the way at all and I was amazed that I didn't pop them. I always pop them in the simulations.

White I was waiting for you to pop one. But I was surprised with the ease I could take them off and put them on weightless. There's just no comparison at all. That's an easy task.

Waste Disposal System

White I thought the defecation bags worked as well as anything we had. There isn't anything you're going to do to make it go to the bottom of the bag when you use it. I think you should be familiar with how to close the bag. I only used one bag and I think you were a two-bag man.

McDivitt I was a two-bag man.

White The stuff didn't float out of the bag or anything. I would permit the thing to remain open while I used the paper. I actually used the paper as kind of a charging mechanism to push the stuff on down in the bag. You know, like loading the cannon. Then I sealed it up on top. There was a tendency for the fecal material to be up on the stick part, which made the closing not quite as nice as I would like it to be, but I was able to close it up all right. I broke two of the disinfectant bags and I cut the bags. There were two different kinds of disinfectants. One of them came in a bag inside a bag, and the other just came in a bag. I was a little suspicious of that one, so I cut it first and I think you did, too.

McDivitt I did that to a couple of mine. I still think that those bags break too hard. I hate to have to cut those things before I stick them in there. I cut one and the darned thing floated back out again and I didn't notice it. I had the bag just about sealed up when I noticed this thing floating around in the spacecraft. I had to push it back down in there.

White When I cut it, I got the stuff on me and a little bit around. The two that I broke, that were contained inside the plastic bag, seemed to work all right. On the whole, I was satisfactorily pleased with the defecation bags. I felt also that the liquid was easy to work into it. I think that's a satisfactory system.

McDivitt You really have that knack of kneading.

White One thing, it is just like oleomargarine was -- Ha! Ha!

McDivitt A little different in color. Ha! Ha!

White One thing that I want to comment on was the toiler paper with the darn wax job. I did not think the toilet paper was satisfactory. It had a waxy back so that it was like the back side of a Sears Roebuck Catalog.

McDivitt That was not the side you were supposed to use!

White I know it, but the other side had such a small amount of absorbency. This is why you always used so darn much paper, Jim McDivitt. Ha! Ha! I found that the tissues we carried in the little containers were very satisfactory for the purpose. I think they can leave the paper out of those bags and provide us with adequate tissues. While we're talking about these tissues, let's go into the container.

McDivitt That's right. The container.

White Yes, the container failed. Both of them failed in a similar manner. We had tissues just loose. They were tucked in around the spacecraft.

McDivitt The zippers that went around these tissue bag holders ripped out completely. Actually, they just separated--almost immediately, as soon as we took them out of the bag.

White And both in a similar manner right off the bat.

McDivitt So we had a bunch of tissues that were not contained in anything.

White I think the containers were very good containers. The method of dispensing would be fine, but they all fell out the side. That's the way I used mine for the rest of the time. I used those tissues for all kinds of things. I cleaned my window with them. I cleaned the camera lenses with them. I cleaned

my visor with them. I got my visor so full of salt spray. Remember when I got that salt spray all over them during the EVA and my visor was dirty? I cleaned everything all up. I substituted it for the toilet paper in the defecation bags. I think this is another thing I am certainly glad we requested. We started out by requesting lens tissues, and as it ended up, this is what we got.

McDivitt We wanted one little bag and ended up with two big bags, and I think we could have used another one.

White I used every bit of mine. I think I could have used them more properly if I had a good dispenser system. I'd grab too many.

McDivitt Those big towels weren't too bad, either. They're great for sopping up the urine and stuff.

White Yes, they were great urine mops. If we had had a big spill of some kind, that's what you'd want to use, because you could use it, it would dry out, and you could use it again.

8.9 Biomedical

McDivitt We have already discussed this in great detail with the doctors so I think we can go over it briefly. The Medical Data Pass Type 1 was not an inconvenience. It got the data down to the doctors quickly. I think it made them happy. It wasn't a big drag on us. Medical Data Pass Type 2 was only about half of the Type 1. It wasn't bad and the doctors got some use out of that. The food evaluation was discussed with the medics so we can just summarize.

White I think we should put a big gold star on the food. I think it was one of the most important parts of the mission.

McDivitt That's right. It was really good.

White Both morale wise and just keeping your strength up.

McDivitt It was a good picker-upper when you felt lousy. The chow tasted good. The thing I didn't like about it--I think it gave me a touch of the GI's.

White I think it tended to loosen you up a little bit. I think, now as I look back, I would prefer to have maybe two of the items in one of those plastic containers and two hard items.

McDivitt Gee, I thought the way they were mixed up was pretty good.

White Sometimes though, you'd have four rehydrated and nothing crunchy. One time I had one that was all crunchies, just about. It had one drink in it. Every bag that I had, except one, that had any form of an orange drink in it, leaked.

White Mine started leaking too, as soon as you mentioned it.

McDivitt I only had one other bag that leaked, or maybe two other bags that leaked. I think that the rate of leakage was just unacceptable. I think those bags are going to have to be fixed.

White No toast.

McDivitt We didn't open up the toast.

White Well, I ate that one thing of cinnamon toast.

McDivitt I ate the cinammon toast because you discovered that it had a coating on it and it didn't crumble so much.

White I guess there was only the one cinnamon toast.

McDivitt Over all, I thought the food was good and there wasn't too much of it.

White That peanut stuff also kind of crumbled.

McDivitt Yes.

White I think we ought to include more meats. I think the bacon was outstanding.

McDivitt Oh, that bacon was absolutely great.

White I could have had that every day.

McDivitt Ed doesn't even like bacon!

White I could have had that kind of bacon. That was kind of a smoked bacon.

McDivitt It really was good.

White When I ate it, I got to thinking that I don't understand why we don't have more meats in the smoked capacity.

McDivitt That's what I was thinking--smoked beef and smoked barbecue.

White Yes, that's very good tasting and it's salty. It makes you drink water, and drink water is what you should do. But I think we ought to look into some of this. Another comment too, is that Jim had thrown the sausage out prior to this time and the sausage that I got was a completely different breed of eat. It was in one of those water bags.

McDivitt I never did get any shrimp. Boy, I bet it was in the last day's meal.

White The sausage was pretty good. There was one thing that I didn't eat and that was one chicken bite, because it coated my mouth. I actually ate two or three of them.

McDivitt The only thing I didn't eat was the bacon and egg bites, either.

White I think if I had my druthers, I'd take bacon.

McDivitt One of the biggest problems on the whole flight was the lack of sleep. I don't really feel that I got more than 6 hours of good sleep or even 6 hours of medium sleep in the whole 100 hours we were up there.

White I think if I estimated my sleep time I might estimate more. I got that one 5 hours. That was good.

McDivitt Ed had one real good one and there were a couple of them where I didn't wiggle around for about 5 hours but never did I sleep more than 2 hours.

White You weren't soundly asleep.

McDivitt I just sat there and I rested. I had one 1 hour period right there at the end that was pretty good sleep and I had another good 2 hour period.

White That mike was one of the reasons we were getting poor rest.

McDivitt I think there were two reasons. One was the radio was feeding into our headsets all the time during the first half of the flight. The second half of the flight we had the darned OAMS thrusters going so much--BANG, BANG, BANG, BANG, BANG!

White I was just too hot some of the time.

McDivitt Yes.

White Early in the flight the ammonia fumes kept me awake. The first time I tried to go to sleep they kept me awake.

McDivitt I don't even know if they kept me awake.

White I really noticed it then.

McDivitt I think we really need a sleep period longer than the 4-hour sleep period. First of all, we always fooled around and . . never really got the sleep that we wanted. If we had gotten a 4-hour sleep period every time it was scheduled we would have been in great shape. I think we ought to schedule a longer one on the order of 6 hours. Ed and I talked about this earlier. What I suggested is that we schedule four 6-hour sleep periods, if there aren't a lot of experiments that have to be done together. Where two of these sleep periods come together, you can make that a dual awake time so that the people could be up. As a matter of fact, you could modify it in such a way that if you wanted two people to be up at the same time you could really have three periods during the day. You could take two of these 6-hour sleep periods and really make them sacred so that nothing could touch them. Then you could just take those other two 6-hour sleep periods and maybe chop periods off each end of the thing, in such a manner that you'd be able to get one good sleep period and some rest periods in between. I think, during a 6-hour sleep period, you ought to plan to be in a drifting flight and not do any experiments. I really think there ought to be one long sleep period with no radios and no thrusters firing. Then you've got a real chance.

White You might be able to put it in Horizon Scan.

McDivitt Well, even then it goes THUMP, THUMP, THUMP, every once in a while, you know.

White I think you could almost do this by ear. If it was bothering the guy you shouldn't do it. In my opinion, I think we're pretty close to the same thing. I had originally told Chuck I thought that the 4-hour sleep period wasn't satisfactory. We should have one period of 6 hours of sleep, with another rest period scheduled in there sometime of several hours. This would be satisfactory. I felt we were really productive when we were both up. I would like to see periods of time in the day where each of the guys are up at the same time and doing actual experiments and work. When you are working

together like that, it seems you are complimenting each other, and I think you get more productive observations. Some of the experiments require two guys. D-6 is going to require two guys. D-9 requires two guys, and to adequately do it to get the pictures we want, you just need two guys up.

McDivitt Let me modify that position of mine even further. If you scheduled a 6-3 and then the other guy with a 6-3, that would leave you 6 hours up together every day. I think that might be adequate.

White You should also always try to schedule your eating periods so you aren't eating during this up time. You should schedule your eating when the other guy is sleeping.

McDivitt Right.

White Go ahead and eat when you just get up, and the other guy is asleep. Eat just before you go to sleep, and don't eat simultaneously. Eat while the other guy is sleeping. I think you should spend all the time, while you are up together, working on productive experimentation.

McDivitt Yes. I think you should keep these two 6-hour periods inviolate and then make the other ones really flexible where you could move those sleeping periods around.

White If you got tired you could go on and take 4 hours for sleeping. If you needed it, you would go on and take longer. If you only needed 1 or 2 hours, you could go ahead and take that. I didn't feel as strongly as you about being tired. You said I was tired.

McDivitt You commented on it a number of times during the flight and also you looked like you were tired.

White Several times I missed a rest period. I think we got fouled up a couple of times on it. I did get tired before I took that 5-hour rest. I knew I was tired.

McDivitt You had that one really good sleep right around 85 hours or so that really seemed to pick you up.

White It helped me a lot. When I came out of it, I really felt groggy until I had had a few minutes to wake up. I think this picked me up considerably and probably this gave me a little gain on you as far as the rest of the flight goes.

McDivitt That's right. During the time you were sleeping, I fell asleep. I saved one night cycle out and went to sleep. Ha! Ha!

9.0 OPERATIONAL CHECKS

9.1 Apollo Landmark Identification (D-6)

McDivitt The equipment we carried onboard the spacecraft really didn't apply exactly to D-6. We didn't have a Questar lens. The 200-mm lens that we carried did not have the periscope mounting for it. It did not have any way you could aim it with a telescope, so the only aiming device that we had onboard the spacecraft was the gunsight mounted in the left hand window. The cameras that we used for this experiment were the 16-mm movie camera with 5-mm telephoto lens on it and the fixed mounted 35-mm Contarex with the 200-mm lens. The fixed mounted Contarex was in the right-hand window, and the 16-mm camera was in the left-hand window.

White It was kind of interesting since we were in free drift, and they told us to go ahead and run a tracking task. But the first one that I ran was Apollo run no. 1, which was over the junction of the Blue Nile and the White Nile in the middle of the delta of the Nile River.

White This was identification and acquiring it and seeing how well the charts that you had equipped you to identify specifically the landmark in consideration. The first one I had was the junction of the Blue Nile and the White Nile, and more specifically it was a little island in there, and it was the northernmost tip on the island. I realized as we came around that I was going to be in pretty good shape in this free drift to be able to see the targets. As we came around, I looked out in the general direction that I had been instructed from the ground, and the first thing that I noted was the major Nile coming down to the intersection. I was able to follow it pretty clearly down to the intersection as we got roughly 20 or 25 degrees from the vertical. I was able to pick up the little island in the junction of the White and Nile River, and I was able to follow it all the way through as we passed over. As we got to the 90° point overhead, it was quite easy to track with my eye. I wasn't actually tracking it. It was northeast of my track 92 miles, so it was really quite far away even when I was at the 90° point. I reported that I thought this was a very good landmark. It was very easy to see, and I felt if I had a higher power telescope, I could have tracked it quite adequately. I classed this landmark as being satisfactory, and I classified the charts that I had used to identify it for me as being

quite satisfactory. Incidentally, I believe that this, of all the landmarks we had, was probably the easiest one of them all to locate, being right out in the middle of the desert, pointed out by two rivers converging from a major river. It was a very good landmark.

McDivitt Okay. You ran some more -- just Apollo landmarks. It wasn't really a tracking task problem. Didn't you run one off of Puerto Rico, too, or was this the only landmark that we really ran?

White This was the only real Apollo landmark I ran. I ran some D-6 landmarks.

McDivitt Okay. Fine. I think the next one that we ran was a border pass on El Paso. Or did you run on Tel-Aviv before that?

White I'm not sure exactly the sequence in there.

McDivitt Okay.

White I think before that, though, I did run a series on D-6 targets 11, 12, 13, and 18.

McDivitt Okay, why don't you go ahead --

White Shall I discuss those?

McDivitt Yes.

White Okay. 11 was Agadir, Morocco, 12 was Wheelus, 13 was Alexandria, and 18 was Dhahram. They gave me all these four targets, and I realized right away that I couldn't possibly handle this many of them and do it adequately. This was the first time we'd been given the go-ahead for some tracking on which we could use OAMS. I elected to use pulse as a fuel conservation method. I selected to try Wheelus and Alexandria, since I thought that I could locate them quite easily, and that they were sufficiently far apart to track adequately. As we came up on Wheelus (I'd been stationed there prior to this time), I knew pretty well exactly where it was. As it turned out, there were some high clouds over Wheelus, and I wasn't able to observe it. Number 13 -- I picked up Alexandria and took manual pictures with the 200-mm Contarex. Since I was actually taking the pictures, I had to divert my attention a little bit to the camera, so I didn't actually look down, and, I didn't actually see the airport. But I had seen it

prior to that time, and I did see it many times afterwards as we passed over. The recommendation that I made from this was that the targets should be far enough apart to allow adequate set-up, to go from one target to another. I thought the updates were good, and the general location of them with respect to my orbits was good. And the next one is El Paso International, Jim.

McDivitt Okay. This was the first tracking task that we were going to do with the telescope, the 16-mm movie camera, and the fixed 200-mm lens on the Contarex. We started out with a time of closest approach and a time we should have been able to see the target. The only kind of identification assist that we had at this time was a piece cut out of a WAC Chart, that showed El Paso International, and the world chart with a gigantic scale on it. This made it a little bit difficult from an acquisition standpoint. But later on we found that these same two types of information -- the world map and the small WAC Chart -- were adequate for other types of targets. The WAC Chart showed, of course, the range of mountains just west of El Paso and the White Sands and the Rio Grande River. We came across Southern California, and I could see the Salton Sea. I didn't track them, but I looked out the front and I could see the mountains of New Mexico and Arizona. And I saw a bunch of white places down below us, any one of which could have been the White Sands. If I could have really picked out the White Sands by themselves, and unfortunately they were off the WAC Chart that I had, I think the contact would have been good enough for me to pick up El Paso. As it was, the only features I had that would have been of great importance were the river, which was the Rio Grande River -- and at that point was not very noteworthy -- and the mountain range, which from the altitude of around 90 miles or more couldn't be picked up. I think that this type of a topographical or geographical feature, like a valley or a mountain, is not adequate for this kind of task. You need a contrast in color as you get from the White Sands to the surrounding desert. The best of all is a water-land interface or border. As we came across the United States, I think we picked up El Paso just as we were over it, but we weren't pointed down at the town. We were still pointed down at the town. We were still pointed well out in advance. The only clue that we were over El Paso was that I could see the Gulf Coast. I knew that when I saw the Gulf Coast we were probably too far along to pick up El Paso. Rather than just scrub the run, we went ahead and made a run on a pair of sand spits with a channel between them in the vicinity of Corpus Christi. We picked up a target well in advance, and

as I started trying to line up on the target, I found out that the gunsight had a light intensity and the gunsight was inadequate for a daytime tracking task; because as you pointed the sight down and had a background of clouds, you just absolutely could not see the sight. I didn't have any idea in the world where it was pointing. When you put it on the dark land, it seemed to be adequate, but I think we can increase the intensity of the gunsight by quite a bit. During the nighttime you can turn it down and the brightness is just about what you need. We made this run on this pair of sand spits, and the tracking task was quite easy. Now, I just happened to pick something that was obvious to me and tracked on this and picked it up while we got on at about 30°, until I got to the vertical, and then I tracked it out to about 45° past the vertical. This wasn't a real tracking task, in that I didn't select a target before I got there. But, I just stuck with whatever target I happened to be pointing at and ran the tracking task. I think we learned something from this pass in that we want to be very careful about picking out targets in the middle of an area where there aren't any good water-land borders; there aren't any good contrasting colors. There wasn't a really prominent feature that I could start from, that worked down to the city and eventually to the airport. So, I think that on this particular pass, although we didn't get any pictures of our intended target, we learned quite a bit from it. I don't believe I have any other comment on that pass. Do you?

White — No. I was quite surprised when we missed El Paso. Remember we thought, "Boy, this is one we're going to nail."

McDivitt — And the funny part of all this is that we had both flown in and out of El Paso International Airport no less than a hundred times. We were pretty well assured of where we were going and what it looked like. But we didn't find it early enough. We progressed too far before I really saw the town, and even then I didn't see the airfield because I wasn't sure I was over the right town until I was over it. And then, it was too late to look at the airfield.

White — I think that the point that you're making is going to be well brought up in what I'm going to say next.

McDivitt — Okay. Why don't you -- you made the next pass, I think, on Tel-Aviv.

White — The next pass was run number 6, target 15. The information I got was adequate to locate it. It turned out that this

target had the essentials that Jim was looking for and mentioned on his last pass. I had a nice body of water. The Dead Sea was a good location, and actually the city itself was located at the end of the Mediterranean, so I felt that landmark-wise, I had a pretty good target to track. I came in and the first target I picked up was Jaffa, and I was on it so well that I decided to go ahead and track Jaffa. At first I had thought it was Tel-Aviv, and a few seconds later I realized that it was the city 10 or 20 miles north of Tel-Aviv. The reason I picked it up so easily is because there was a little spit of land that jutted out into the water and it sat right in this little natural basin. I looked down and I saw Jaffa and I actually saw the little round circular airport in Jaffa. I also saw Tel-Aviv, and I saw the airport that I was really looking for, but I decided I'd go ahead and track Jaffa and take a few pictures of Jaffa as we went over. You have to realize that I wasn't using a gunsight on my side, and I was also controlling the spacecraft and firing the camera at the same time. So the tracking is probably a little rougher than it would be from the left-hand side. But I did get a good indication of the capability to track a target and to pick a target up, and I think that I was quite surprised at the ease at which you could track. I also concurred with Jim's conclusion that a good prominent landmark primer, preferably a body of water somewhere to nail down your target, is the most desirable feature. I also feel that an important thing that the next crew going up could do would be to spend a lot of time on just plain map study in the 30° north to 30° south, and try to pick up the prominent features to permit them to become quickly adjusted to what they can see and what they can't see down below. I think that a little concentrated map study prior to the flight would help a lot with the D-6. Also a concentrated study on the targets themselves would be quite beneficial. This is something that we really never got to do. The original 243 targets were to voluminous even to consider time to study each one, and when we got the final 19 targets, it was pretty late in the flight to be working on an experiment that wasn't even on our flight. Even with the limited knowledge that we had of the targets I felt that acquisition and tracking of the targets was a lot easier than I had thought it was going to be. I guess that's all.

McDivitt The next target that we had was Yuma International Airport. Here again we had a target that was not a very prominent landmark. The time of closest approach and acquisition time and the aiming angles were adequate. It gave me a good

idea of what I should be looking for and when I should be looking. I used the same maps again; I used the cutout of a WAC Chart plus a great big world chart. There was quite a discontinuity in the scale of these two maps, but I'm not really sure that we couldn't have done the job with just those two. I think that what we probably needed was a world map that showed a little more detail and a WAC chart that showed a little bit more area. What we probably could have used most of all was a photograph of the area. As I came in across the California coast, I picked up the Salton Sea and El Centro, just below the Salton Sea, and then I knew that Yuma was on the Colorado River, which should be a few miles to the east of the Salton Sea. There was a nice big bend in the Colorado River. Unfortunately, the Colorado, although it is a reasonably good sized body of water -- if just plain doesn't show up that well. It was a little difficult to see, but I finally picked it up. I saw the bend in the river. The river doesn't actually go through the town of Yuma, so I started looking for Yuma, and I did wander around a little bit before I finally found the town. Then I was unable to find the airfield within the town. When I was just about directly over the airfield, I picked it up. Here is where I think the photograph would have been a lot of help, because the map that I had just showed a yellow blob indicating the city with a circle to indicate where the airfield was. It showed the airfield to be to the south of the town. What I was looking at was a large group of buildings, the town itself. Then as I went to the south, I saw even more buildings and I wasn't sure whether the airfield was south of that built-up area. As it turned out, it was south of the main built-up area that actually had another large group of buildings south of it. I did pick up the airport itself at just about 5° before the nadir, and I tracked over to the target, probably just at the nadir and just shortly past. I had the 16-mm movie camera going with the telescopic lens on it. I had the gunsight on bright. I used Pulse Control Mode. I got right on the target and I managed to fly the spacecraft in such a manner that the gunsight never deviated from the target by more than a half a degree, I feel, if it deviated that much. I think it was considerably less than that. But there wasn't any great difficulty in the tracking task, and I managed to control in all three axes and hold the target just about where I wanted it. Here again we had a problem with the contrasting target; the water-land mass was quite some distance away. In this case, how far is it from El Centro to Yuma?

White I don't know, Jim.

McDivitt 150 miles?

White Yes.

McDivitt It was a reasonable distance, probably something on the order of 150 miles or maybe only 100 miles, but the problem was that between Yuma and El Centro there weren't any identifying masses that led you toward Yuma. And I had not up till this time looked down to try to find where the Yuma airport was, because we'd been saving fuel. So, this was the first time that I'd seen Yuma airfield from orbit. As I get into the next target, I think you'll see what I'm leading up to. Having a first look at a target like this, being able to identify the city, but then essentially wasting time before I found the airfield within the city, I think, cost some valuable time and consequently cost some good pictures; because the best picture is going to be that picture which is taken exactly over the airfield.

White That wouldn't happen again though, would it?

McDivitt No.

White You'd probably have it pretty well nailed.

McDivitt No, it wouldn't. So, the next target I had was Cairo -- Cairo International Airport. Now, we'd been over Cairo quite a few times before this, and I had looked down to find Cairo. I think we had had an Apollo landmark or D-6 type of thing, where we were supposed to look down and just acquire the target, but not actually track it or take any pictures. When we did come by, we could actually look down and find the city of Cairo the first time we came by. Later I found the Cairo Airfield, and Ed and I were discussing Cairo Airfield and Alexandria Airfield. We both had one in sight. When I picked up the Cairo Airfield (I was told to pick up the Cairo Airfield), it had all the ingredients that I think is necessary. I had seen it before. I knew where it was with respect to the local landmark. The local landmarks were the Mediterranean on one side, the Red Sea on the other side, the Suez Canal connecting these two large bodies of water, and a river leading from near the Suez Canal over toward the city and the airfield. Then, knowing the position of the airfield with respect to these landmarks, since I'd already seen it, I came in over North Africa along the Mediterranean Coast with no platform on, just in Pulse Mode, no attitude reference, found the Mediterranean on my left, pointed the spacecraft on ahead, determined the direction I was going,

picked up the Red Sea, picked up the Suez Canal between the Red Sea and the Mediterranean, and followed the river in. I started this quite a distance out. I knew just about where the airfield was, but it wasn't coming into view. Finally, at about 20° before the vertical the airfield finally came into view. I tracked on the airfield about 10° before the nadir. I was tracking the area in which I believed the airfield to be, so that I had already had the pitch rate set up that I required of my spacecraft. As I got on the target I still had to track in multiple axes, but I already had the rates built up, and I tracked from about 10 to 20° before the nadir to 45° past. I think this will probably be the best tracking experiment that I did. Later on, I had another one. Later on I had another tracking task against Basra in Iraq on the Persian Gulf. Here again, we had the ingredients that were necessary to pick up the target. We had a large body of water, a river leading up to a lake, and then the airfield sticking out in a very prominent way. Now I'd never seen the Basra Airfield before I tried to take this picture. But the landmarks near it were sufficient so that finding the location of it was not difficult. There weren't any towns around. It was pretty obvious from the bodies of water where I should look for the airfield, and I picked it up also 20° before I got to the nadir and was on it by the time I got to the nadir. I tracked it from there out to about 45° past. Once again I had a reasonably good tracking task. I think that on the tracking tasks on Yuma, Cairo, and Basra, I managed to keep the target within the center half-degree circle of the sight. I used the 16-mm movie camera with the 75-mm telephoto lens on each one of these cases. Did you have any other targets, Ed?

White No.

McDivitt I don't believe you did. I think the big thing here is that you've got to be able to have a landmark that stands out long before you get to the target. You have to have a lot of contrast.

White Or some real technique or type of familiarity with the target. I think if you were really familiar with the area you might pick up things that we don't pick up now, but we could with a little more map study and study over above.

McDivitt That's right. I think that the first thing, though, that you need to help you find the target is a really contrasting thing. Now the next thing is that you've got to be familiar with the target, as Ed said. Now if you have never been

there on the ground and don't know what it looks like from there. I think what you need are a few passes over the target to study it from the air, and look for it from the air, and try to pinpoint in your mind the local terrain features and local contrasting features that will help lead you to the airfield. Because it looks to me like it's easiest to find a target when you're exactly over it.

White Boy, you're right. There's a point when you pass over the top where everything really is clear.

McDivitt The big thing is either a lot of target study on the ground or a previous pass across the target so that when you go across it, you not only know the general area that you're supposed to point into, but the exact spot where that target is and some identifying features that will lead you to this target. So with the initial things like a lot of contrast to get you in the area and then a lot of detail gathered either from target study or from a previous pass across the target, I think that you could go ahead and find it. Once on the target the tracking task in the Pulse Mode is not difficult at all. I think you can track within just tenths of a degree of the target without too much difficulty whatsoever, in multiple axes. And I found that without having the platform up every tracking task I did was in multiple axes, and although you're going through some very peculiar maneuvers, it's very instinctive to track up and down, left and right, using the gunsight, without any regard to what your attitude with respect to the local horizontal is. In air-to-ground gunnery you sometimes find that you've got to pick your attitudes up from the ground. They sort of tend to be a constraint on what you can do, but that's not the case in this kind of a task.

White The thing that really amazed me, Jim, is the first time I saw an airfield from up there. First time I saw one, I saw it directly from overhead. I was amazed at the clarity with which I could see the field. Although, of course, I saw no airplanes sitting on it, I felt that I was seeing down to a resolution of 50 feet or better with my own eye when there was a contrast of some type available to me. In general, I thought the clarity of things that you saw was far better than it is from just flying at 40 000 feet. Things are much smaller, but they are much clearer to me. Also, at night things are much clearer. And over one town we passed in Australia the lights were very, very clear down there to me. I think that with some type of an optical aid we can see a great deal. I think that with cameras with higher

power and more capability, we can take pictures of a lot more down below. I think that the only picture I've seen so far that I thought would be nice from a tourist standpoint is the one I took of the Cape, which everybody seems so excited about right now. That's one that was taken with the sun on the window and at roughly a 30° angle down from the horizontal, which indicates you're shooting through a lot more atmosphere than necessary. The clarity was quite surprising, even to me. You can count the launch pads and see sizes of buildings. Because of the oblique angle, you can actually measure the sizes of these buildings. I think we've got a tremendous amount of photographic potential from in space. I think that Jim and I mentioned a little bit earlier that the area capacity inside the spacecraft limits the capability to carry a good size telescope or a very big piece of camera equipment. I think that coupled with the EVA capability that we have, we can carry some equipment back in the adapter -- some nice sizable cameras and telescopes -- and build mounts on the outside of the spacecraft. We can go EVA, pick these pieces of equipment up, bring them out, and mount them on the sides of the spacecraft so that we can take a series of pictures and use really good, big, higher-powered telescopes for observations. If we do mount them out there, of course, we should mount them somewhere so that if we had a failure of some kind and had to come right in, or weren't able to open up the hatch again, we could separate them by some type of pyro. But I think that is the one way we can combine our EVA operations with the desire to bring up big pieces of equipment and operate them with our spacecraft.

McDivitt I agree. I think that the possibilities of viewing things on the ground from space are practically unlimited, and I was quite surprised at the ease with which you can control the spacecraft and take pictures and I was surprised at pictures you get. We've got an awful lot of work that we can do in this area. I think the technique of acquiring these individual targets needs a lot of work. I feel that the best way to do it, if you're going to be limited to one pass over the site, is to use a photograph of it made from some previous time. I feel that the need for a large landmark nearby, especially a water landmark, is pretty great. I thought that the information that we got from the ground of what time we would be over the target and what time it would be 30° below the horizontal were excellent pieces of information. It certainly contributed a lot to finding the target. I think there's an awful lot of work that we can do in this particular area. You have anything else, there, Ed?

White No. Oh, this is one thing that I have been bubbling about the last week or so, wanting to tell somebody, and haven't been able to tell anybody. I couldn't, of course, tell it in the press conference. I really didn't want to talk too much about it at the meeting we had before with everybody, but I think this is one area in which a tremendous amount of capability exists, and I think we'd be very foolish if we don't work further to exploit it.

McDivitt I concur.

9.2 Apollo Yaw Orientation

White Okay, I'll probably go into this a little bit, and then we can go over the data on it. This was a fairly simple test. All we did was start at a zero-zero reference and establish rates of 3 degrees/second simultaneously in all axes. We had a secondary objective, to see when we established these rates and put them in three axes simultaneously if we got a scanner ignore light. And I'll clear that one up really quick. We put them in at two different times and neither time did we get a scanner ignore light. We did this at night the first time, didn't we? That was really the only time we did it.

McDivitt Just the night one. That's right.

White That's right. We did it once at night. I established the rates in three axes and allowed them to build up for about 30 seconds. Then, I told Jim to go ahead and take control of the spacecraft, and using visual references to move to a retrofire attitude.

McDivitt I did this is Pulse Mode, I believe, because we were trying to save fuel. I think I did it in Direct, but I did not do it in Rate Command. I did it in Direct. The first thing I did was try to find the horizon so I would have some reference point to start from. This was quite easy. I just had to wait for the spacecraft to move so that I could see the horizon in any position, and then I went for it. The yaw reference, though, wasn't present when I got to the horizon, so I ended up level on the horizon upside-down, but without a yaw reference. I pitched on down well below the horizon so that I could look down at the ground. Watching the clouds go by, or whatever was down below me, I could pick up the direction of my motion. So, I rolled around such that I was pointing down at the ground, probably $45^{\circ} \pm 20^{\circ}$.

I rolled around until my head came up, and all I had to do then was pitch back to the horizon to get to the 30° nose-down attitude for retrofire. This took 2 minutes and 20 seconds. Now I did this trying to save fuel. I could have done it much quicker if fuel wasn't a constraint. Also, I think I learned something from this in that I made a mistake by going first to the horizon. I should have pitched down until I was pointed straight down to the ground, picked up my yaw as quickly as I could in this position, rolled around so that I could just pitch straight up, and end up at the horizon blunt-end-forward, heads up, and wings level. I think I could've gotten it down to about a minute and 20 seconds. I felt that I wasted a minute doing this.

White You were taking it slow.

McDivitt Okay, now, I'll go through the Apollo Yaw Orientation debriefing here. The Control Mode, as we said, was Direct when Ed put me into the condition. I used the Direct Mode, I believe. I damped out the rate without any difficulty at all. The orientation, I've already gone through. What I should have done was to go nose-down. What I did do was that I came to the horizon first, tried to find a yaw reference and couldn't, then went down to the ground. I should have gone straight down to the ground. The time, as I mentioned, took 2 minutes and 20 seconds. I feel that I could have done it in a minute and 20 seconds. We did not get the scanner ignore light due to acceleration, but we did get the scanner ignore light when we finally got to a position where we were outside the attitude constraint of the scanners.

White There were a couple of things. As far as the initial rates were concerned, they were $3\frac{1}{2}$ degrees/second roll-right, 3° pitch-down per second, and 2° yaw-right per second. The final orientation that Jim came to was such that his pitch was on, his roll was on, and his yaw was off by 18°. We found early in the flight that a yaw reference at night on the stars, particularly on a dark night, was very difficult.

McDivitt Yes. I still thought that the quickest yaw reference was to go to the ground.

White As far as the day check, we decided that the night was by far the tougher case, and it didn't seem to be too difficult. So, we thought that since the day was so easy we wouldn't even go ahead and do it. The orientation by day was a quite easy thing.

9.3 One Attitude Thruster Failure Check

McDivitt Okay. We'll just go right through the debriefing here. It was not difficult to establish the rate as long as we had the roll jets in the other axes. We could damp out the rates. We used the Direct Control Mode. It's just pretty straightforward. It's identical to the simulator. We didn't learn anything new from this check except that the simulator was indeed correct. Do you have anything to add?

White No. That it was pretty straightforward.

9.4 Horizon Scanner Track Check

McDivitt Horizon Scanner Track Check is next. The horizon scanner ignore light came on as expected except the attitude band through which the horizon scanner operated was considerably broader than we had expected. The scanner ignore light went off again at the proper attitude, considering the fact that the scanner ignore circuit keeps the scanner ignore light on 7 seconds after the scanner has relocked. So, we always had the scanner ignore light go out at a different attitude than where it came on because of the fixed rates we were using. We went through the zero bank angle, pitch-up and pitch-down. We went through the zero pitch, bank-left and bank-right. We then got to the roll with pitching. Here, I only banked to the right and pitched up and down. I didn't bank to the left and pitch-up and down. We did the pitch with rolling, and here I pitched up and rolled left and right, but we did not do the pitch-down, rolling left and right because of a fuel limitation and a time limitation. We had another experiment that had to be done. We had to get the platform off and we had a limited amount of time to accomplish this. I sort of felt that the check was very well accomplished at this time. The data are in the data book. I saw no need to waste time doing the other two maneuvers, expecially since we were so limited on time and fuel. Did you have anything to add to that, Ed?

White No. I think that the remark that the data are in the book is adequate.

9.5 Horizon Scanner Check

McDivitt The first one is the sun. I think the best way to do it is to have Ed read out the comments that we wrote in the data book as we did this. We started with the blunt-end into the sun.

White We started blunt-end into the sun and we got the scanner ignore light momentarily as the sun hit the scanner head.

McDivitt It went right out again. It went out in 7 seconds like it was supposed to.

White Right. It was just a momentary light and 7 seconds later it was off again. Going back around to the 180° position, we didn't get the scanner light again. Again in here, we got a scanner ignore light when we were faced right into the sun with the nose, and it went out again and came on once more, and then stayed out.

McDivitt So, sequentially, we started with the blunt end into the sun and started a yaw to the left. As soon as we came around into the sun we got the the scanner ignore light, and it went out a short time later. We came around right into the sun, and at this time the scanner ignore light came on, went out, and came back on again. Is that correct?

White Yes, and then finally stayed out.

McDivitt And stayed out. Then we yawed back around till we were blunt-end to the sun again, and yawed back into the sun, and back around blunt-end to the sun again, and we did not get any more scanner ignore lights. The next step is the Moon Scanner Check. We did this with the moonset and, Ed, you might add the time that we did the Sun Scanner Check.

White The Sun Scanner Check was at Greenwich Mean Time of 11:50. We'll have to correlate that later.

McDivitt I think that we were supposed to be in the blunt-end to the sun configuration at 11:54 and start there, but I'm not really sure about that. Okay, the moon check was performed just about like the sun check. We started blunt-end to the moon and made two cycles. Blunt-end to small-end and back to blunt-end, and small-end back to blunt end. Ed, go ahead and read the data.

White Okay. On the moonset, we started with the moon quite high, so we had a good moon. We started at 12:17. We had no scanner ignore lights for the first 180° and, actually, throughout the next cycle we had no unlocks or any lights for two cycles.

McDivitt So this was completely normal.

McDivitt The thrusters check number 3 -- we turned the spacecraft, since the thruster firing wouldn't influence the orbit except to change it slightly, and we went ahead and fired the forward-firing thrusters for 1 second. We didn't get any change in our scanner ignore light configuration. It was out and it stayed out during the entire thruster check. So I guess that it operated all right. We'll summarize all of our scanner comments at this time.

White You want me to read some of these?

McDivitt Yes. Why don't you read off some of the comments you have in there.

White They're in your writing. You might read the first page and I'll read the second, since they're in mine.

McDivitt We went to Horizon Scan Mode of control for about the last day of flight, and left it in that mode just about until we retrofired. I'd like to read out some of the comments that I made here as we lost the scanner, when we got the scanner ignore light. At 16:03 Greenwich time, or about 72 hours elapsed time, I turned on the Horizon Scan Mode in about a 25-degree nose down attitude with a pitch up rate of about 2 degrees/second. The Horizon Scanner Mode added pulses to the pitch up rate and increased my rates to something considerably above that, but then as we came up into the Horizon Scanner Mode deadband, it started pulsing rapidly and killed off this rather large pitch rate and held the spacecraft right in this attitude. So, we had a very good acquisition of the mode from a somewhat undesirable condition. At the first sunset, the scanners were pointed right at the sun, but did not break lock. We did not get any scanner ignore lights at this time. Later on, at 17:04, about an hour later at sunrise, the scanner ignore light came on with the spacecraft pointed in such a manner that the small end of the spacecraft was pointed about 45° to the right of a line drawn directly between the spacecraft and the sun. So that, essentially, the sun was shining on the horizon scanners at

about a 45° angle. The scanner ignore lights stayed on for 10 or 15 seconds, and then went out. There were no false pulses from the jets at all. At 7:55, just at sunset, again in about the same position, I was 45° to the right of a line drawn between the spacecraft and the sun. The scanner broke lock. We started pulsing down for two or three pulses, then stopped, but the scanner ignore light stayed on longer than 7 seconds and then it went out. We pulsed up one or two times to start recovering from these initial two or three pulses that started us down, and then the light came on again. It was only off for about 2 or 3 seconds, just a very short time. We were at about 30° pitch-down at this time. We then started pulsing pitch-down rapidly with the scanner ignore light on. We pitched down and did a 360° maneuver in pitch; we started just about horizontal, pitched down till we were looking at the ground, continued pitching down with respect to the spacecraft until we were horizontal, upside down, now facing the opposite direction than we'd started, and continued pitching down with respect to the spacecraft. The small end ended up straight up and we continued pitching down again until we started coming back down to the horizon. I did not at any time during this maneuver attempt to control the spacecraft. The pitch-down thrusters continued to fire throughout the maneuver at intervals like there was indeed a signal coming from the Horizon Scan Mode. As the spacecraft started back down toward the horizon, I thought sure that the horizon scanner would catch the horizon, because at this time the sun was no longer right on the horizon. However, we developed a slight amount of roll during the last 120 to 150° of pitch, and as we went down through the horizon, we were out of limits in roll and Horizon Scan did not pick up the horizon. I then took over the spacecraft and maneuvered back to a position from which the Horizon Scan Mode could reacquire and put it in this condition. It stayed locked on. Ed has a few notes here. We'll have him read his.

White About the only notes that I made on the scanner was that at sunset and sunrise it had a tendency to break lock. I have a note here that at 22:22, at sunset with the sun right on the scanner, that is, 90° to the spacecraft, the scanner broke lock three different times. At 22:58, at sunrise, the scanner put in spurious inputs but was able to control and didn't lose lock. Sunrise seemed to be the time at which the scanner had the largest tendency to break lock, and if it didn't break lock, it would at least put in spurious inputs which were obviously not required other than due to the confusion factor that the sunrise was causing on the

scanner. Again, I have one at 11:58, at sunrise, the scanner 60° to the sun, broke lock once and pulsed quite a few times extraneously, but caught itself and continued to track. I think on the whole that the scanner worked real well.

McDivitt So do I. As a matter of fact, I believe in the last 20 or 24 hours, however long we had the Horizon Scan Mode on, that we only really lost control of the spacecraft that one time, where we did the pitching maneuver I've already discussed. I think in every other instance, although it pulsed needlessly two or three times at sunset if the scanner was pointed toward the sun, it never really lost lock and it certainly never lost control. The light would come on every now and then, but it would --.

McDivitt But, I don't think that the light came on more than three or four times in these last 24 hours.

White No. They sure didn't.

McDivitt And even though the light wasn't on, it seemed like we would get an extraneous pulse every once in awhile at sunrise or sunset. But I thought that the Horizon Scan Mode worked very well. It certainly proved to me that it was an excellent attitude-hold mode, or pilot-relief mode.

9.6 HF Transmission Reception Check

McDivitt I think that I'd like to start out with number 3 in this case. We received an update to start and stop our checks and had no difficulty doing this. I think that the transmission and reception, number 1 and number 2 under this major heading, are covered in our data book and I'd like to have Ed summarize them at this time.

White We ran a 1 day and 1 night long test on it in which we attempted to have all stations contact us. The data in the book. I think the data will point out that the HF is a rather unsatisfactory mode of reception. It was difficult for us to evaluate our transmission that'll have to be done from the data from the stations. But as far as reception was concerned, we got a little bit during the night and just about nothing during the day. We ran also a sunrise and sunset check and we made the long counts as indicated, and listened for any return on all our HF tests from Thule and Elmendorf. We could hear Elmendorf calling us, but

they were at one time barely readable, and most of the time you could hear somebody trying to call, but they were very broken and difficult to read. More detailed data are in the Flight Data Book.

9.7 Orbit Navigation Check

McDivitt Following the format in the debriefing guide, I think that the maps and overlays that we had were excellent. I felt that the concept was a very good concept. It gave us a good check on where we were throughout the flight, as far as accurate times went. We used at times the other track charts that were printed before the flight. We found that these were off some fair amount, although they furnished good information also. Once we had the time error that we could apply to times listed on the map, we found that we were able to use these quite well also. I think that the map and the overlays that we used in our Orbit Navigation Checks were a very good scheme. The control mode we used was Pulse, and the timing was just the G.m.t. timing we had in the spacecraft. I'd like to have Ed discuss a little of the technique now.

White Actually we had a form in our book that we had made up to make these tests, but I think it became apparent to both of us as we came along that this is a fairly simple thing to do. If you want to just try to update your map without having an update from the ground, it was quite simple to point the spacecraft straight down to the earth and get a point which you could recognize on the ground, and actually plot this right out on your orbit map. I think we could probably make checks in this manner and update our map almost as well as we could by having a longitude and time called up from the ground. I'd like to make a comment right now that I thought the little map that we had with the orbit plot on it was very useful, but it was weak in one respect; I was always wanting more detail on what I was seeing down there. We, fortunately, carried a map with about two to three times the detail of the section cut out of a Mercator Chart, which I found very useful. By properly folding a map, I think I would prefer to have a map of even higher detail with me. It didn't seem to me to be a drawback to have a large map in the cockpit, as long as you kept it folded down in the proper manner. Do you have any comments on that?

McDivitt Well, I agree with Ed. I thought that this was a relatively simple task. I felt it would have been much easier to do if we had the platform up so we could point the spacecraft down using inertial reference and using the platform, but it wasn't difficult to do it just visually. It only took a short time to plot up a couple of points and run back and determine your own ascending node.

White You know, another thing that I found very interesting was when they called up plot points and they'd give you 30° right, down 45°. Even without the platform, those meant a lot to me. I could visualize very easily where I was going, whether I was small-end-forward, or blunt-end-forward. I could visualize quite well, without a platform, 30° down and yaw 30° over, looking for a point. It seemed I could check points nearly as well with or without the platform. It wasn't hard to orient.

McDivitt I think that's probably true. I do think that this is a good scheme. I'd like to see us continue it on future spacecraft.

White Yes. I'd take it again if I had my druthers. What do you feel about a bigger map?

McDivitt I think for this kind of thing, this Orbit Navigation Check, the map and the overlay we had were about the right size, but when we got around to looking for things on the ground, I thought the maps and charts we had were pretty inadequate. I'd like to see us get something with more detail on it, just the way Ed says, and I think we will cover this in be better detail when we get over to the Apollo landmark thing.

9.8 Relative Humidity Test

McDivitt Another operational check that I'd like to discuss at this time is the Relative Humidity Test that we did during the flight. All data are in the data book, but the thing that I'd like to say most of all is that the relative humidity was considerably less than anyone had ever expected. The cabin temperature was less than anyone had ever expected, and although we were instructed to measure the cabin wall temperature with a thermistor that was on the end of our relative humidity gage, I found that this was pretty difficult to do since they'd covered the entire inside of the spacecraft with the sponge rubber. We couldn't find a good

place where there was just bare metal. I took some measurements on the inside of the left-hand side food box. I took one or two readings off of the metal frame that went around the window. Those are the only two places I was really able to contact spacecraft metal. Do you have anything else that you want to add to that, Ed?

White No, the data are pretty well laid out in the data book. I don't think there is anything else. It did surprise me, and it was a very pleasant surprise because I was interested in taking my gloves off and putting my visor up. I sure did as soon as I found out it wasn't going to get wet.

9.9 Zodiacal Light Check

McDivitt I'd like to have Ed describe this.

White Okay. We did this one on the fourth day at 22:42 Zebra, and it was one on which procedures were called up. What they wanted to do was find out if the thrusters firing could cause any interference on some Zodiacal light photography that was planned on later flights. The first test was to pitch straight down toward the earth, open the shutter on the Contarex camera and actuate the pitch-up with the shutter open. Then we'd take another picture and actually open the shutter again and activate the pitch-down thrusters, to see if these two thrusters would cause some type of light interference to the photography. On the pitch-down part of the phase, we waited till the moon had set, and as we were pointed down toward the earth, we came upon an area fairly clear of clouds. But, unfortunately, there were a few scattered lights from homes or cities down below us, which might have caused some interference. I don't think so. They were very, very scattered. The pitch-down test was satisfactory. The next one was the one in which we were actually level with the horizon. Again, Jim opened the shutter, I actuated a pitch-up, and closed the shutter. He opened it again, I actuated a pitch-down thruster, and he closed the shutter. It was a pretty simple test. We took four pictures.

10.0 VISUAL SIGHTINGS

10.1 Countdown

McDivitt — During the countdown the visual sighting I had was a multitude of wasps sitting on the R and R section and crawling all over the windows. Aside from that, the sky was clear and I didn't see anything else except the gantry going up and down.

White — That's about it. It appeared to me the wasps were somewhat confused. They felt that the RCS nozzle was a very large beehive for them.

10.2 Powered Flight

McDivitt — The first topic is lift-off. At lift-off I was looking at the instruments and didn't see a thing. I think Ed's got something here.

White — From the lift-off -- I could actually feel when we lifted off -- the vibrations decreased a great deal.

McDivitt — What about visual sightings?

White — I'll get to that. As we started to move, I felt I could see the relative motion. We had a clear blue sky above us; there weren't any clouds, but I could see the motion in the sky. I could also, as soon as the roll program started, definitely see the rotation of the booster and spacecraft combination. As we continued on up, I was watching within the spacecraft and outside, also. I could see the pitch program initiated. I could hear Jim call it out, and I could actually see it on my instruments and also see it out the window. BECO's the next topic.

McDivitt — Why don't you go through that. I think I just looked out one time to see the horizon for just a second. Why don't you go through the rest of those there and read them off?

White — Okay, at BECO I was looking in also. I was waiting for the staging and I had my attention inside, and I didn't see the big sheet of flame that John and Gus described coming from around the separation of the first stage. So, there wasn't anything other than the normal feeling of the separation.

As far as visual sightings were concerned, I didn't see anything else at staging. As we started to nose over, I saw the horizon coming up and I called that out to Jim.

McDivitt I think that might have been when I looked out, but I'm not really sure I could see anything at the time.

White I had to say something. It is quite an impressive view when you're up there -- the very first time you look out and you see it. I looked out and all I could see was the horizon and the blue down below us. You probably couldn't, because as I think of it now, we were on the side. I could see the horizon and you couldn't. All you could see was the sky.

McDivitt Right.

White So I could see a little of both. I could see the clouds, the water, and the whole smear. The first time I saw that out the window I called that out to Jim, and it was quite an exciting view.

White Engine number 2 ignition -- I didn't see anything that had to do with lighting the second engine off. The horizon view, I just discussed. At SECO, there was a lot of debris going by.

McDivitt That was at spacecraft sep, wasn't it, rather than SECO?

White You're right. You're absolutely right. At SECO, I didn't see anything other than that the acceleration profile went down to zero. At spacecraft separation, I think Jim and I both noticed a lot of stuff coming by the spacecraft.

McDivitt Right.

White Just plain debris was all it was. Just pieces of white junk came by.

McDivitt Probably little-bitty pieces of the adapter there.

White In fact, when I got out and looked later on at the spacecraft separation plane, there were pieces of the same kind of white stuff still back there attached jaggedly to the adapter section. Fairing jettison--I couldn't see that. Did you see anything on the fairing jettison?

McDivitt When I jettisoned the fairings, I saw the horizon scanner fairing go whipping off, but I couldn't look at it and the

nose fairing both. So, I only saw the one go, but there were some more pieces flying all over the place, and they went just as soon as I punched the Fairing Jettison Button.

10.3 Orbital Flight

White Boy! We've been talking about these things for the last 10 days. The first one is geographical.

McDivitt Yes. Geographical. We could see wakes of ships. We could see roads. We could see towns. Although I never saw any individual houses, I could see an industrial area with what looked like oil tanks and a few other things. We could see canals very well. We could see the Suez Canal very well from the air. I don't think I ever saw an individual ship. I never saw any individual cars or airplanes, but you could see runways very well. But the thing that you could see best of all were long lines. I'm sure that if you had a road that was 50 feet wide, or however wide you make roads, and it was long, you could see it. Whereas, if you had the same thing and it was just a square down there, I doubt very seriously that you could see it unless you were looking for it, specifically.

White I think perhaps also there is the contrast between the colors. The things that I saw with very high clarity were runways. As you looked down at the runways you caught a high contrast between the green or the brown, or whatever the color that it was laid out in. You could see it very clearly. I was impressed by how clear you could see things. They were small; there's no question that things don't get any bigger when you're looking down at them, but in my opinion things were much clearer. I could see with a higher detail than I could when I fly over in a normal airplane, as far as the object itself being clearly defined. I also noticed this at night when I looked down on it. In the clear stretches the city lights were much finer defined than the lights are in a city when you're flying over at 40 000 feet. Things are small but have a much higher definition. I think it would be interesting to find out in our photographs the degree of resolution that you have. I feel that the resolution, if you have the proper contrast, would go down to 50 feet or below.

McDivitt Yes. I'd agree with you there. Geographically, there were just so many things that we could see. I think that we took

pictures of most of the things that we thought would be interesting.

White I'm dying to look at those pictures.

McDivitt Me, too!

White I agree with Jim that if you look at a city, particularly if you look at a city in a desert area where the houses are brown and the surrounding terrain is brown, everything's kind of small and it all blends together. Unless there was some type of contrast between them, it's pretty darned hard to pick up a city right out in the middle of the desert. We had trouble when we came to El Paso in finding it, and Cairo blended right in with --

McDivitt -- blended right in with everything. You could see the airport at Cairo -- I'm not sure if I ever did really see the city.

White I think I could. When I was looking in that area at Jaffa, as soon as I saw that airfield out there and was concentrating on looking at it. I saw more detail.

McDivitt Yes. The thing of it all is that, geographically, you have to have a real large feature to be able to see it very far out in front of you, like the Red Sea. Now when I was trying to find Cairo one time, I looked out, I was having trouble finding the Red Sea. Pretty soon I found the Red Sea about 30° below the horizon or maybe a little more. As I got closer, of course, the Red Sea stood out very well. As we get closer and closer, these things really start standing out, but when you're looking from up around 125 or 150 miles, and you're out 60°, you're a long way from your target. It's just that you can't see that far through all that atmosphere, I guess.

White I think one more comment on the geographical is that I think we're really going to see some things down there when we get some type of magnification.

McDivitt Yes, a telescope is what you really need.

White If you can get some kind of telescope to help, I think we can really see something. I wonder if there isn't some way that, while we know we can't carry some things inside the spacecraft, we can work with something outside the spacecraft -- camera equipment or some kind of optical equipment

that we might be able to have mounted on the outside. We can store it somewhere and mount it on the outside after we get up there -- mount a telescope right through, with the eyepiece on the inside.

McDivitt Boy that would be great! Wouldn't it?

White And then when it comes time to come in, you just punch the thing off and forget about it. But while you're up there you've got this thing with the long eyepiece. I think we can do this with EVA. Stow the thing back in the adapter, go back and get it mounted up, get back in, and you've got youself just about as long a telescope as you'd want to put up there. Same way with cameras. I think you can take cameras up. We can take some of these big cameras that we've been wanting to use. We can have a sighting device so that we can mount this thing on the outside of the spacecraft after we get up there, and then point it with a pointing device at the ground and get some of these pictures that we've been wanting to take. I think we've got some possibilities there.

McDivitt Okay. Celestial. I think in the nighttime you can see the stars without any difficulty. In the daytime you just can't see the stars if there's any sunlight whatsoever on the window, or if the nose of the spacecraft is in the sunlight, of if the horizon is in the sunlight, or if some of the earth is in the window. I think all these things tend to limit your night vision. They create an optical barrier, practically, between you and the stars. The difference between the day sky up in orbit and the day sky here is, as far as we were concerned, practically nil, because there just weren't any stars visible. It didn't have anything to do with the atmosphere; it just had to do with the optics of our window and the nose being shiny. We couldn't see any more stars in orbit than we could here in the daylight, but it wasn't because of the atmosphere up there. It was just because we had that coating on the window that reflected the sunlight, and because the nose reflected the sunlight into the windows, and the same thing with the horizon on the ground. When it was lit up, it reflected light into the windows. Actually, you had to get that window in total darkness almost before you were able to see anything.

White Pull the shades.

McDivitt Pull the shades. And then when you did that, you were able to see some stars. On a few occasions when I got the

spacecraft into this particular attitude, I was able to see some stars in the daylight. How about you, Ed? Were you able to see any stars?

White — Yes. I called them out a few times. You did have to maneuver just as carefully --

McDivitt — That's right. You had to be just exactly in the right spot.

White — Let's go into the magnitude of the stars. We had set ourselves with the Corona Australis as a kind of calibrator for us, and this was composed primarily of fifth order stars. That was very clear, and I could see without any difficulty stars of lower magnitude than that. I could see, without question, stars to the seventh magnitude.

McDivitt — And that's exactly the same magnitude I would guess. You could probably see them down to a magnitude of seven.

White — Now, another thing, though, was that the sky wasn't any more full of stars to me there than it is when I'm flying at about 40 000 feet on a real dark night.

McDivitt — No, as a matter of fact, it didn't really seem to be as full of stars.

White — No. On the night when we were flying with that eclipse of the moon, I saw more stars than I've ever seen in the sky.

McDivitt — Yes, and as a matter of fact, I wouldn't doubt that we could go out here and fly tonight and see seventh order stars.

White — I bet we could see lower than that.

McDivitt — That's right. What I'm leading up to say is that I don't think we could see as many stars in orbit as we could flying around in an airplane at 40 or 45 000 feet.

White — That's exactly my conclusion also. You could see down to the seventh order stars.

McDivitt — Yes, and I think the reason for this is the coating on the windows, don't you?

White — I think so. I felt that there was just a little shield of what I was really seeing.

McDivitt If we'd just gotten that coating off, we'd have been in great shape.

White I also noticed a tremendous difference if I turned those lights off in the cockpit. It was just like turning those stars on on the outside, and I don't think we should take those red lights out.

McDivitt No. I don't think so either. You know, the thing that did look brighter to me was that planet right over by the sun. When the sun set, that planet would really stand out.

White I noticed another thing on the planets. I didn't notice -- which one is in Leo now?

McDivitt I don't know.

White It's Mars. Mars is around Leo now, and it didn't look as orange. To me it looked roughly the same color as Venus did, and remember I remarked on that up there, which is a very interesting thing now. I presumed that the color should stay the same.

McDivitt I didn't notice any difference between it up there and here on the ground.

White It didn't have to me the characteristic orange color that it has when I look at it from down here. It looks more like a regular old --

McDivitt A regular old star, huh?

White No, it looked like the planets, and remember I remarked on that.

McDivitt I think you did, now that you mention it.

White And we probably went on doing something else and forgot about it. Let's talk about the airglow.

McDivitt Why don't I discuss that thing that I saw those two times at night.

White Yes, I saw it too, so you weren't seeing things.

McDivitt This phenomenon occurred in the dark and I think it was near Australia each time, but I'm not really sure. We've got it

recorded on the voice tape, so we can go back to the voice tape and see where it was. They were just parallel running lines of lights radiating from the earth up toward us out at a distance away, and it sort of looked like a curtain. All of these lights' rays seemed to be sort of parallel to each other. They looked a lot like the Aurora Borealis, except that they were down below us and they were coming up toward us. The first one we saw was considerably brighter than the second one and it was sort of wiggly. It probably had five or six curves in it, at least, and I thought it went like this a couple of times, and was bent up around like this.

White — How about in the airglow layer?

McDivitt — Was it in the airglow layer? No. I don't think it was in the airglow layer. It looked like it was down underneath -- it looked like it was right over land and was considerably closer to us than the horizon was. It was, maybe, halfway between us and the horizon. I got the impression that it was a lot closer to us and it was definitely not in the airglow layer. Both times I had this impression. It looked like it was coming up out of some clouds. I could see the clouds down on the ground, and I had the impression that this was coming out of them, but it only got to an altitude of maybe half of ours. That would be up to 50 or 60 miles. This is the impression I got. I took some pictures of it too, didn't I?

White — I had the feeling that the first time you took it you had the wrong setting. You had about 250 at an f11. I don't know what you did the second time.

McDivitt — I don't remember, either.

McDivitt — This thing was in motion, too. It wasn't a stationary thing. It continued to move the way the lights on neon signs do. It was wiggling back and forth.

White — When it came around over toward my side it was, to me, closer to the horizon, and it looked more like it was below and in the airglow.

McDivitt — It looked like it was in the airglow to you? When I saw it, it definitely wasn't in the airglow. It was a lot closer to me.

White — Of course, it started on your side and you talked about it for 3 or 4 minutes or so. Then as we drifted around, it went over, I guess, to my side. It was irregular shaped and it was out toward the airglow layer.

McDivitt — Well, the second time it was a lot less bright.

White — Are we going to talk about the airglow layer now?

McDivitt — Okay. We're going to talk about the airglow layer, but it comes under "horizon." Let's talk about that under "horizon."

White — Okay.

McDivitt — Do we have any other celestial observations? The fire flies that we had around the spacecraft continually -- sometimes you'd be able to look out and only see one, and you couldn't see them too well at all at times. You could see them in the daylight occasionally, but I don't think you could ever see them at night. But the place where you could really see them was at sunrise and sundown, because here you had a black background of the sky and you had the sun shining on them.

White — They picked the sun up.

McDivitt — They picked the sun up and reflected the rays. They reflected them just as bright as stars, I thought.

White — Didn't they! Well, you know the thing that was most interesting to me was the time I called you and said the sky was full of stars, and you said it wasn't the sky. We were pointing down at the earth. That was my first exposure to having your window in the daylight and mine in the dark. At this time we had all the fuel particles from the fuel from the boosters spewing out all over, and my whole view out the window was just completely full of these reflecting particles. They looked kind of like one of the star fields we had passed off on us as star fields. It looked kind of like a star field, but it looked kind of unreal, too. That's exactly what it was.

McDivitt — One of the prettiest things was when we had a urine dump at sunset, because we just had millions and millions and millions of these fireflies or particles outside. When you put them all out like that with the sun shining on them, as we'd mentioned earlier with the black background, it just looked marvelous. As a matter of fact, we took some movies of them,

and I think we might have taken some stills, but I'm not sure.

White I hope it came out.

McDivitt Yes, it was really spectacular! So we could just about make our own stars when we wanted to. Is that all on celestial?

White That's all I can think of, Jim.

McDivitt I couldn't see the Zodiacal lights. I couldn't see the Gegenschein and I could not see the burst of Zodiacal lights that you get just as the sun sets. Go ahead, Ed.

White Okay. I saw one during the last few sunrises. I watched the sun very carefully from the time it first started to come up till it finally popped up. I was looking all the time for that shoot of light that's supposed to come up just before the sun pops up. Well, I could never see that. All I could see was the glow as it came up and a very rapid rise as the sun did come up. There's something that I did see that was quite interesting to me. Several minutes before the sun came up there would be a shaft of light that would shoot up, and I watched it on two different occasions. It was during your last sleep. I was taking a few final movies and I was watching for this very phenomena. It was the first time I saw it. It would be a little shaft of white illumination and it was a long time before the sun came up. I don't know whether that's what they were seeing before or not. But when the sun itself actually came up, I didn't get much of a big ball of light -- just some big, bright lights coming up from behind the earth.

McDivitt That's all I was getting. I didn't see this other thing.

White I saw quite a few shooting stars.

McDivitt Oh, yes.

White They seemed to fall and burn up considerably below our altitude. They looked a half or a third as high as we were when they were actually being consumed and being burned up. I never saw one above us, did you?

McDivitt No. Okay. Cloud coverage --

White There was a lot of it.

McDivitt There was lots of it. There were a lot of times when there wasn't any. I don't guess there's much we can say about this.

White I think we took some good pictures of the clouds.

McDivitt Yes. Well, throughout the 4 days we had cloud coverage over things we wanted to take pictures of. Other times we didn't have any at all. It was a variable thing, and we just got a lot of good cloud pictures, I hope. Horizons - well, at night there was a definite dark horizon, which I assume is the earth's horizon. And then there's a dim band, and then above that, there's a bright band that is much narrower than the dim band, and above that it is clear, and then nothing. I guess there are really three horizons. There's the top of what I think is the earth. There's a top of the dim band, and then there's a top of the bright band. In the daylight you don't see these dim and bright bands. It's just a gradual decreasing in intensity of light. It starts out with a very light blue at the horizon and just gradually goes out to the dark blue, and it finally just goes to black. Right at sundown, if you're pointing 90° to where the sun is, you can see the light blue of the day sky coming down. It's much, much higher than the airglow that you see at night.

McDivitt If you're looking over at the daylight side, it looks like the light blue goes up probably three times as high as the airglow does. What do you think about that?

White Let me go into my impressions of the airglow in the evening. I saw the same thing you did, of course, and it looked like to me that the dark part was roughly two or three times as thick as the lighter airglow layer below it. We were both impressed with the phenomenon of the apparent rise in the airglow as you go from the daylight to the dark, and as soon as you get out in full daylight, the earth's layer is all gone. But as you transition between the daylight and the dark, you see the layer start out and narrow down to what you see as you get into the dark side as the airglow layer. And when you initially get into the dark area, the airglow seems to disappear for a moment, and then the airglow layer pops out when you get into full dark, very clearly.

McDivitt I agree. Okay. Do you have anything else?

White That horizon isn't very good on the daylight side, either.

McDivitt No, the horizon isn't very good on the daylight side.

White The horizon's not very good anywhere, really. We'll go more into that on D-9.

McDivitt You could see the lights of the attitude thrusters, and it didn't seem to make any difference which ones you were firing at night. They weren't blinding by any stretch of the imagination.

White They looked like lighting maybe. Little flashes.

McDivitt The attitude thrusters lit up the sky a little but not a great amount. They weren't blinding either. Not much to say about that. Okay. I want you to discuss adapter separation that you saw.

White Okay. On the adapter separation, Jim and I agreed to separate the electric and the OAMS, and then pause between the adapter separation so that we could dwell a little bit on the separation and absorb as much as we could about it. When it did separate, we got a very clean feeling of separation between the two and a very definite feeling that the adapter and the spacecraft had separated. There wasn't much question in my mind. Was there much in yours, Jim?

McDivitt No, not at all.

White There were a few pieces that came around from it, but not as much as there was at spacecraft separation after insertion. Did you see anything?

McDivitt No. I didn't see anything off the adapter.

White All right.

McDivitt The equipment adapter. I just saw it off of the retro adapter.

White Why don't you go to retrofire then?

McDivitt Okay.

White Do you have anything else on the adapter separation?

McDivitt No, I don't think so.

White I was impressed with the cleanness in the feel, and I didn't even want to look around. I just happened to be looking over at Jim's window at that time, and, as I said, I could see pieces go around, and I could especially see pieces to this side. What I saw looked like a mount with two round things on it. I had been briefed on this thing by John Young, and he said it looked like two pump packages. So, I said it looked like two pump packages, too. Looked like just what I expected it to. And there was lots of debris around it as it whistled off to the side, and then it went out of my view.

McDivitt Okay. On retrofire there weren't any sightings to observe. Did you see anything outside, Ed? Did you see any flames or anything like that?

White No, I didn't.

McDivitt I don't think there was much there. The retro pack jettison -- we didn't see it jettison, but shortly after that we had rolled upside down and we were flying in, and I saw the retro adapter floating around on the left side. It had turned around so that it was small-end-forward rather than blunt-end-forward. You could see the whip antenna sticking out the side, the four retrorockets, crossbeams, and the plumbing around the edges. It was quite a sight. It drifted out behind us until it got out a couple or 300 feet. It started glowing a little on the leading edge. It started fading farther and farther behind us as we reentered. It finally went from a dull glow to a bright one, and finally you could see the leading edge of it eroding away. Finally, it was just a ball of flame back there.

White I thought that was quite a sight, too. It kind of set the modes for our reentry, of observing very interesting things all the way down, including ourselves.

McDivitt We didn't observe anything in particular that happened at 400 000 feet. The ionization was where we really started picking up the fire.

White I think we kind of timed that with what you were talking about the retro adapter up there. You said, "Hey, look at it starting to burn!" and about that time we were starting to throw a sheath around us too.

McDivitt That's right. It looked like to me that it went from pink to orange and then went out to a reddish-orange, and then

in the midst of the reddish-orange you could see little tongues of green occasionally. It was quite pretty.

White — I think another thing about it, too, is that there wasn't as much of it as I thought there would be. I can't say that I was disappointed in not seeing more fire, but when I first heard about John Glenn's reentry, I envisioned more fire coming out. In this case you might call it just a sheath.

McDivitt — That's right. There wasn't a big blaze, by a long shot.

White — It was almost like a veil of silk. There was no flame.

10.4 Reentry

McDivitt — Well, in reentry we rolled. We didn't have any trouble in seeing the horizon as we went around, but we were rolling all the way down. We did see ourselves crossing the ground, since we were heads-up a fair amount. We could look out and could see anything we wanted to see. I saw the Gulf Coast, and then out across Florida.

White — A little bit of dizziness was associated with the rolling reentry as far as the visual --

McDivitt — Yes. It wasn't really dizziness. It was just the fact that you could tell that you were going around in a circle at a relatively high rate. It didn't bother us. It's just that you could feel it. The spacecraft didn't oscillate very much during reentry. Anything else there, Ed?

White — No.

McDivitt — When we deployed the drogue, it really made the ride interesting. I couldn't see the drogue very well. Ed could see it probably better than I could. At this time, I didn't know where the sun was. We oscillated back and forth on the drogue probably as much as ±40°. I never did see the drogue dereef. I couldn't see up to the top to see if it was reefed or not.

McDivitt — I don't think there's much else about what we could see on the drogue. Can you think of anything?

White — I could see it up there whipping back and forth, and I was sure hoping that it was going to hold on and not pull the front end of the spacecraft off, the way we were oscillating.

McDivitt At R and R separate, I saw parts of stuff out in front. My window was pretty well clouded over, and I couldn't see that well. I did see something separate, and I did see the chute start off. It went all the way up. At main chute deploy, I saw it come out in a reefed condition, I checked the chute, and I didn't see any panels missing. I checked the little circle in the middle in the parachute, and it seemed to be in fine shape. I was expecting that we had a good chute. It finally just dereefed and we had an excellent chute. It popped out and came back in. About a quarter of it along the edge folded back in and then popped back out again and we had a beautiful chute. Do you have anything else on the main chute?

White No. I couldn't see it until it started to dereef. From the dereef on, I could see the chute and was very happy to see it.

McDivitt During our descent to landing, I could see the R and R can with both the drogue and the pilot chutes attached to it, floating off to one side. After we landed, I noticed that there was steam coming out of the RCS thrusters. This steam didn't last very long. I could see the sea dye marker in the water. I could see the parachute in the water.

White I think you also ought to indicate that the windows steamed up quite a bit. I could see out a little better than you. You couldn't even see 50 feet out in front of you on your side.

McDivitt No, I sure couldn't. There was a hole down at the bottom of the window that I could see through. Ed wasn't having too much trouble seeing through his. It was real nice to see the helicopter and the swimmer.

White Both the windows were pretty foggy, though.

11.0 EXPERIMENTS

11.1 Two-Color Earth-Limb Photography (MSC-10)

White — This is one in which we had our first example of poor flight planning. They scheduled our MSC-10 experiment so that it actually conflicted with some Horizon Scan Tests that we had to make. And since our Horizon Scan tests were being made in conjunction with the platform, which was only going to be up for a limited period of time, we had to interfere on the tail-end of MSC-10 to go ahead and start working on the Horizon Scanner Check. Anyhow, we went ahead on the MSC-10, starting at 11:04, and went through eight series of pictures. This was the time that we had trouble with the event indicator.

McDivitt — Didn't we have ten series? I thought we had ten.

White — I've only got eight indicated here. Oh, yes, wait a minute; it says $10\frac{1}{2}$ runs. I only have eight recorded here, and a final one being run at 11:57. We should have $9\frac{1}{2}$ runs.

McDivitt — Yes.

White — We should have $9\frac{1}{2}$ runs, and only nine were required. We should have it all. On the first three runs, the event indicator wasn't used, because I was having trouble with the Hasselblad shutter working properly in conjunction with the event indicator. About 11:19, I got the event indicator working all right, and the rest of them were run pretty well. The early runs were taken pretty much in night conditions. I doubt if much will come out on that one. The next one, at 11:09, was taken with the sun right on the horizon, right into the camera, so I doubt if that one will be too much more than a big washed-out mess. The rest of them were all taken with the horizon in the proper position and utilizing the ring sight. The last part of the experiment was interrupted by the Horizon Scanner Tests. In other words, we didn't get to the sunset. I think actually the sunset would have been one more series of pictures.

McDivitt — I would think so.

White — Okay. I guess that's all for MSC-10.

McDivitt Okay.

White Do you have any comments on that?

McDivitt No, I don't have any comments. I think we logged the time and the weather along the route, such as it was, and we got all that into the book.

11.2 Synoptic Terrain and Weather Photography (S-5 and S-6)

McDivitt I think we had a lot of unusual and significant subject matter, and it's all in the pictures. We had one camera that wouldn't wind the film too easily, but other equipment operated fine. We didn't get the data reviewed properly -- too late.

White And we used the voice recorder as often as we could record. I don't believe we have all of this S-5 and S-6 photography recorded. I think as we go over them, though, the ones we didn't record will be pretty obvious.

McDivitt Yes, I think that those two experiments are really in the photographs. The Hasselblad camera operated fine except we had one magazine that didn't wind up too well, but it never did jam up completely. I guess that sort of covers it. Wouldn't you say, Ed?

White I would too. All the data that we got for it is recorded in our data book. Let's see. Simple Navigation with the Sextant. Ha! D-9.

11.3 Simple Navigation with the Sextant

McDivitt I guess we might as well cover it.

White Well, in the Air Force portion of it, we can start right off by saying that the stars they wanted us to run the operation on -- I think, Series Number 4 --

McDivitt No, that was the last one. They gave us Series 1 to start with.

White -- which was the daylight. The daylight operations didn't prove feasible at all. We couldn't see the stars and if we could have, we didn't have a good horizon to run them on.

So it became apparent to us that that run was lost right in the beginning, when we first came out of the darkness and lost all the stars. We also got the big picture that the sextent was not going to be too easy to use. It was going to be impossible to use without using some fuel, and it was going to be damn hard to use when we used just pulses of fuel. We needed some kind of stabilization. At least I thought so.

McDivitt We might say that the lightbulb in the counter readout for the angle was burned out.

White That burned out within 2 seconds after we got up there, I think.

McDivitt Did it ever light?

White First time I turned it on it lit and it went "flit," and then the light just went buzz-buzz.

McDivitt I didn't know it ever lit.

White It lit and then the light went out.

McDivitt Okay. So we lost the lightbulb in the angle readout, which made all the rest of the measurements very difficult. And the Air Force portion in daylight was completely unusable. You couldn't see the stars and the horizon at any time. In the night portion, we initially had great large angles between the stars and the horizon, and we found that about 25° was the maximum star-horizon angle that we could handle. Would you concur with that, Ed?

White Sure do.

McDivitt As we mentioned when we were talking about the horizon and the airglow, we really had three horizons. We had the true earth horizon. We had the top of the dim airglow layer, and we had the top of the bright airglow layer. I think that I used the top of the bright airglow layer, except where I specifically called out in our notes. Ed tended to use different types of horizons, dependent upon the type of filter he had on. Why don't you discuss that a little bit?

White I tended to feel that the bottom of the bright airglow layer gave me a little finer defined horizon for a no-filter operation. When I put the blue filter on, though, I didn't have much horizon at all. When I put the green filter on, it

gave me, as far as the top of the airglow is concerned, a better horizon to measure to. I thought that the horizon was certainly not a very defined point to measure to, and I think accuracy would be lost in trying to measure to a horizon like this. It's just plain hard to take a fuzzy old horizon and try to make an accurate measure to it. That's exactly the kind of horizon that you've got at night.

McDivitt I concur. There must have been at least a couple of minutes of fuzziness in that horizon, and I don't think that you would ever expect to measure to the horizon within a couple of minutes. Do you?

White No. You'd have to calibrate yourself down pretty close to measure. You know it would be just pure luck if you kept measuring properly to it.

McDivitt Yes, the thing of it all is that even if he got himself calibrated so that he would always measure the same angle between the star and the horizon -- it wouldn't be consistent between one person and another. I'm not really sure how you would ever go about measuring to this horizon with any accuracy at all unless you had some way that you could -- instead of attenuating the light -- build it up in some way and then filter out one particular line that happened to be an extremely sharp line. The horizon I liked to measure best was the top of the dense airglow layer with no filter. The next horizon I liked was the top of the dense airglow layer with the green filter. I liked least of all the blue filter, because it just completely eliminated the horizon.

White Yes, I don't think the difference between the clear and the green was enough to argue over a preference between. I thought maybe I had a clearer one in the green, but I tended to take far more measurements with the clear one, so perhaps they are so closely matched that it really didn't make too much difference.

McDivitt Yes, I did most of mine with the clear one.

White For the runs in the Air Force portion, I found out that the stars had too big of an angle between the star and the horizon. To actually follow the format, for the runs as given, turned out to be too difficult. We did make runs on stars and horizons if we took the time on it and took the measurements. It seemed like the angle was fairly well limited between 20 and 25°. This was due to the limited maneuver

capability imposed upon us and the lack of having enough window space. If you get behind the sextant, behind the window, and try to make a measurement, you might be able to theoretically measure something out to 50 to 60°. Theoretically, this may be possible, but you just can't get yourself up above the console circuit breaker panel or down into the foot well area, which would be required to make measurements of this magnitude. There were definite limitations on hitting the side of the spacecraft and trying to make a sighting and losing the object out of the upper window as you cranked the periscope down to bring the star down to the horizon.

McDivitt In trying to accomplish the Air Force portion of the experiment, we found ourselves completely unable to do the daylight star-horizon measurement. So, to get some insight into the operational use of the sextant, we took a great number of star-to-horizon measurements at night. They are in the book in quite a bit of detail. As we mentioned earlier, the helmet was an impediment to use with the sextant, so on occasion, we had to take the helmet off. The greatest angle that we could normally get was about 25° between the horizon and the stars, but on occasion we got up to 30°. This meant a certain alinement of the spacecraft was necessary so that you could get the largest piece of glass between the star and the horizon and still get the sextant in there. We found out that to do the star-to-horizon measurement, you had to be right-side-up. If you tried to do it upside down, the filter blanked out the star and not the horizon. I think that there are a great number of measurements in here, but I do feel that the Air Force portion of the D-9 Experiment was more qualitative than quantitative. Maybe I ought to talk about the Apollo portion. We made one Apollo run where we used two stars. I held the spacecraft fixed to within about ±2°, and Ed took a great number of measurements. Ed made a great number of measurements between two stars. And we got our 30 runs on one pair of stars that were quite close together. Then we started out with about another 20 sightings on another pair of stars that were further apart.

White They were all in Scorpi. I think they were about 12° on the first one and about 22° on the second one. There were Antares and Scorpi in the second series, and it was Scorpi and the third star up in Scorpio in the first series.

McDivitt Again, we found that the angle that we had selected to operate between was too large, and we ran our first group of stars in

about $12\frac{1}{2}^{o}$, and for the second pair we tried to pick stars that were farther apart so that we could get a better feel for larger angles. This pair of stars was a little over 21^{o} apart. We were too optimistic about the angle between stars that we could see by looking through the spacecraft window. What do you think about the voice recorder usage during this experiment, Ed?

White — I don't know why we had to do it.

McDivitt — No, we actually hand-recorded most of the information here. The one thing that certainly delayed the experiment was the loss of the lightbulb within the readout. We changed the batteries and bulbs from the crosshairs and never could get this particular light to come back on.

White — Did you ever figure out why we needed to hand-record all these things -- why we had to record them on the recorder -- the times and all that jazz?

McDivitt — No, we had to record the angles some place and we had to correlate it to a time.

White — Well, it says to prepare sextant and photo-event indicator for measurements. What do they mean by photo-event indicator?

McDivitt — The photo-event indicator was to get the exact time. Remember, when you were doing star-to-horizon measurements you had to have --

White — No, but this is just for the star. I don't understand the photo-event indicator. I think that just clobbers up our data.

McDivitt — That's right. Yes, that wasn't applicable at all. It didn't make any difference what time it was at all.

White — In fact, when I made a second run on this while you were asleep one time, I didn't put the photo-event indicator on.

McDivitt — No, there wasn't any need to put the photo-event indicator on this.

11.4 Electrostatic Charge (MSC-1)

McDivitt I think what we could say here is that we turned MSC-1 on and off when it said in the flight plan and when directed by the people on the ground.

11.5 Proton-Electron Spectrometer and Tri-Axis Flux-Gate Magnetometer (MSC-2 and MSC-3)

McDivitt We turned off MSC-2 and -3 according to real-time flight planning from the ground and whenever the flight plan in the air called for it.

White We had one time when I ran a double small-end-forward set of runs through the anomaly. The first time, I felt that the heading had not been accurate enough for the small-end-forward requirement. We were doing it without the platform on the stars, and the first time through, I wasn't satisfied with it. So, I called down to the ground and told them that I wasn't satisfied with the run and that I'd make a repeat run the next time. This I did, and I left the equipment on throughout both runs and for an hour after that. So, we effectively have two small-end runs through the South Atlantic anomaly.

McDivitt Okay. We didn't have any operational problems with it. Did we use the voice recorder with it?

White Yes, I guess we did. It should all be recorded on the voice recorder. If not, we've got backup times in the book. Our voice recorder was our prime means, and our book was just a backup.

McDivitt Right.

11.6 Radiation (D-8)

McDivitt I think one time you were sleeping, and you didn't get it that pass, but you got it the second pass, didn't you?

White Well, we got them logged when we did it. They can go back and get it.

McDivitt Right. There were no operational problems. We did use the voice recorder to record the information.

11.7 Inflight Exerciser (M-3)

McDivitt We didn't have any stowage problems with it besides those associated with all the other equipment. The outside thin rubber layer broke on the exerciser about the end of the first day.

White Yes. I've got a comment or two.

McDivitt Go ahead, Ed.

White I had the feeling that my capacity and my desire to do strenuous physical exercise decreased during the flight. Actually, it kind of decreased to a point and stayed at that point for the whole flight. Shortly after I got up there, I really didn't have any big desire to do a great deal of physical exercise. I did do the exercises as indicated, and I did about eight extra series of exercises with the exerciser, but I noticed a definite lack of interest in doing heavy physical exercise.

McDivitt I concur with what Ed said, although I'm not really sure this came about because of the small amount of sleep that we had, or just as an effect of the zero-g thing. I did use the M-3 exerciser to do other exercises. I used it to exercise my arms, not only in the manner that was demonstrated, but by holding on to one end and pulling the other end with the other hand. I used it to exercise my legs also.

White I did a few other exercises, just with the exerciser. I yanked around a little bit on it, as Jim indicated. But, I also did some exercises in which I pressed pretty hard up against the front end of the spacecraft. I tried to tense my legs and tense my stomach and arms, and I tried to exercise in this condition. I probably did that a lot more than I did anything with the exerciser.

11.8 Inflight Phonocardiogram (M-4)

McDivitt To the best of my knowledge, we didn't have any equipment problems. About the end of the second day, my sensors started itching a little. I don't know if it was my phonocardiogram or my other sensors.

11.9 Extravehicular Activity

McDivitt — Extravehicular activities have been covered in great detail earlier in the debriefing. I don't think we have to go over that again.

11.10 Miscellaneous

McDivitt — In the external observations, I did observe three satellites, but I think these were covered in detail earlier, and I don't believe we need to go over that again here.

White — I think that we'll comment again (we've commented on this point before) that the tape recorder is the most important piece of equipment that we have onboard the spacecraft to record our observations, times, and other information concerning the experiments. I think the one we have onboard with the light located down underneath the pilot's right elbow is entirely unsatisfactory. I feel that we lost some information on our flight due to the light coming on and not being observed. We were going ahead with information for the tape, but were losing it in this manner. I think we ought to correct this deficiency prior to the next flight.

McDivitt — I concur heartily.

12.0 PREMISSION PLANNING

12.1 Mission Plan (Trajectory)

McDivitt — It is pretty difficult to debrief this premission planning because we had so many premission plans that we couldn't keep track of them all. I think that we started too late on the mission planning for GT-4, because everyone was concentrating on GT-3. Then in the $2\frac{1}{2}$ months that we had to do the mission plans, we changed it about three or four times, drastically. We not only changed the trajectory, but we changed the altitudes of insertion; at one time we were shooting for a 87-145 orbit and then a 87-161, and then we changed it from 90 degree launch azimuth to a 72 degree launch azimuth. We changed how we were going to handle the decay of the orbit. All in all, I think our mission plan changed just too often.

12.2 Flight Plan

McDivitt — Same with the flight plan. We kept changing it around, and changing it around, and changing it around. It was really unfortunate. Up until about 10 days before the flight we were really prepared for about two different flights, and finally we got the flight plan nailed down. I think our flight, though, was somewhat different than other flights in that we did have some real major changes about $2\frac{1}{2}$ months prior to the flight. Consequently, we had to expect these things. So, I think I'd be the first to admit that I lived with these changes, because I had a great desire to do the mission that we set out to do.

White — We both kind of got to the point where we knew that we had a mission to do, and we knew it was going to be tough as far as getting a good flight plan was concerned, and we were just trying to get the best we could and go.

McDivitt — That's right. I think that the situation that we finally ended up in was that we tried to have a very good launch and first couple of orbits and a good last orbit or two. All the stuff in the middle, we knew we were going to have to handle real-time. I finally found myself forced into the situation where I couldn't even worry about the middle flight

plan. We had to lay it out in general and expect a great number of changes. This is exactly what we did. We handled it in real-time. I'm not suggesting that we do this for future flights, for I really hate to see us go right on down until the last minute before we get this information prepared. I think it's too bad, but I think on our flight a lot of this just couldn't be helped because of the drastic changes in the flight plan in the last $2\frac{1}{2}$ months.

White I don't feel we've got a big beef coming to anybody. I know a lot of people were working pretty hard.

McDivitt That's right. There were a few things on our checklist that could have been done earlier, but I think the total mission plan, as such, was modified at a late date to change the objectives by a great amount. We in the crew agreed with the change. It almost doubled the amount of work that we had to do in those last couple of months, but I think that by accepting it and trying to make the thing work, we were able to overcome the problem, and it was indeed a major problem. A situation that I hoped wouldn't occur and did occur on our flight concerned the checklist, the data books, the procedure books, the map for the orbit navigation, and our charts and graphs. We didn't receive the checklist and the procedure and data books for our flight to look at until 8:00 o'clock the night before the flight. Consequently, we didn't have a lot of time to go through them the way we should have. We should have had these books and charts in our hands no later than 2 weeks before the flight. Here again there were some extenuating circumstances, but I'm not sure that the circumstances were really that great. I still think that we should have gotten these out earlier. The people down at the Cape doing these things worked themselves to the bone night and day, practically, to get these things done. I have nothing but the highest praise for the people from FCSD that came down to do this job. I just sort of suspect that we should have gotten started on it earlier, and that maybe we should have had a few more people down there doing it. Any comment on this, Ed?

White No. This is the thing that I think I was harping about a long time before the flight, because I saw the same thing happen on GT-3, when the checklist came in at the last minute. In fact, the last night before the flight, I remember John walking down the hall looking at his flight plan and his checklist and commenting on this surprise and that

surprise, and there were a few surprises in ours. I wouldn't say there was much we didn't know about, because we had gone over it pretty thoroughly. But all our experimental procedures and our books -- we're partially to blame in some respects also, because we were running the show and knew exactly what we wanted. But I concur very heartily with Jim's recommendation that we get these things made up at least 2 weeks ahead of time so that we can use them in the simulator, and that we use the little hand-held checklist exclusively in the simulator that we are going to fly with, if you could get them nailed down that well ahead of time. That's what I would have liked to have done. That's what we didn't do, though.

McDivitt Yes, I don't really see any excuse for dragging it out to the last day. If these things would have been 8 hours later than they were, they wouldn't even have made the flight.

White I think another thing, too, is that right now we've got a good set of books and checklist. I recommend heartily, unless the crew that comes behind us has some very strong diverse opinions, that they use something similar so that they can get somebody started making them early enough to be useful.

McDivitt I concur wholeheartedly.

White They may not like everything about them, but I think that they proved their value with us in our flight. I sure would rather use something, and use it well, than use something that may be a little bit better, and use it poorly.

McDivitt Okay. I think that covers the flight plan topic, don't you?

White Yes sir.

12.3 Spacecraft Changes

McDivitt Here again we had some changes that were brought about by the change in flight plan, but I think we handled all of these adequately. I just don't think that we ought to use GT-4 as an example as to what should be done on a flight, as far as no change and things like that. I feel that if we don't have the equipment onboard the spacecraft checked out and ready for service by the time the spacecraft leaves St. Louis, they shouldn't fly on the flight. I've felt like

that since the time I got assigned to this flight, and I still feel that that's the way to do it, unless you have a major change for a worthwhile reason.

White I was sure wondering right to the very end if they were going to get these final changes in that were required for our flight. They sure waited a long time to put them in.

McDivitt Yes, 2 or 3 days before the flight we still had a lot of things missing. In fact, when I got into the spacecraft, about the first thing I noticed was that the velcro wasn't around the 8-ball. About 30 minutes later, while we were lying there waiting for the launch, Ed looked up and pointed at the 8-ball at the place where the velcro was not.

White Yes, there wasn't velcro in several places where I had wanted it, and in several places where I had actually drawn in the lines where I wanted them to put the strips. Instead, they put them 90° to where I had the lines. I can't believe they would do something like that. I'm not really complaining. I think they did a pretty good job.

McDivitt Do you have anything else on spacecraft changes?

White No.

12.4 Mission Rules

White I thought this was one of the smoother points.

McDivitt What? Mission rules?

White Mission rules.

McDivitt So do I. I don't really have any comment. I think we had a very good set of mission rules, and I don't have much else to say about it.

White I concur. I think we set a record on running through the mission rules review, and I have one recommendation to make. I recommend highly that the crew review their rules thoroughly prior to the meeting and send their disagreements to Flight Operations Division, so that they can either concur with them and incorporate them, or disagree and then iron the differences out on the major things before you come to the mission rules meeting. Then, you'll find that you sail

right through in just the first meeting, and this is exactly what we did.

12.5 Experiments

McDivitt I think we had some pretty good pre-mission planning on our experiments, except D-6, and I think the people in FCSD, specifically, fell down on the job. The did not prepare the Target Acquisition Folders that we needed. They arrived down at the Cape about 2 weeks before the launch with a foot-thick pile of maps for us to memorize.

White They had a WAC Chart of every place that we were going to fly over, the whole 30° north to 30° south, and that sure isn't what we needed.

McDivitt I think that there wasn't any imagination used here. I just feel that the people who were responsible for performing this duty fell down on the job completely, and did nothing whatsoever but talk about it. When we really got around to flying this thing they didn't have a thing for us. It turned out that the people who finally ginned up the maps for us were the people from the Department of Defense Office here who were monitoring the thing from the technical standpoint. I sort of felt that this target acquisition stuff was a function of FCSD, and as a matter of fact, the people who were concerned with it led me to believe this. When we got around to flying the flight, we found that there wasn't any way to acquire these targets. They hadn't done any work with it at all, so I think that this is a real low point in the FCSD.

White They didn't even have what I would consider a satisfactory method of calling the information up to us.

McDivitt No, to put it bluntly, it was screwed up and unworked upon. I think the planning for all the other experiments was adequate.

White We had one area where we were a bit too ambitious, and this was in the stars for the Air Force D-9. We reviewed this, also, so there was no lack of planning. It just turned out that using these stars in the sequence that we had for them, with the type of fuel constraints that we had imposed upon us, we just couldn't effectively run the experiment without using a great deal of fuel.

McDivitt Yes. And I think that this came about just because of a lack of knowledge on everyone's part, on just what we could handle in the spacecraft, and the rates that the stars move through the skies.

White That was something that we learned on this flight.

McDivitt I think so. I think that's part of the qualitative data that we brought back for D-9, but I do feel that the pre-flight planning for D-6 was completely inadequate. Anything else on any of the other experiments?

White No, I think the other experiments were well briefed to us. We understood them quite well, and I think the procedures were well taken care of.

McDivitt That's right. Let me clarify one thing. I think that the technical aspect of D-6 was one of the best briefed of all the experiments. The DOD people who were responsible for it had some of the most detailed and thorough briefing guides and forms for us on the equipment, and we were more briefed on the equipment. It was just the procedures that were lacking.

White Yes, I felt that I knew the equipment and its assembly and usage on the D-6 backwards and forwards. Procedures for conducting the experiment were quite clear to me, but the only thing that we didn't have was a good method of passing up the targets and target acquisition once we got up there. Also, just handing me 243 targets was a pretty simple-minded approach in trying to solve this problem, I thought.

McDivitt I don't think I have anything else on experiments.

White Nope.

12.6 Training Activities

McDivitt Well, I wouldn't do anything differently.

White Jim, I wouldn't either. That's one of the highlights, I think, of our mission; that we were well trained for it; and I felt in all respects we were well trained. I don't believe I'd add anything extra, and there's nothing I think I'd take out, either.

McDivitt Well, I think that the training went along just about as we'd planned it and hoped it would work. I do feel that the simulators didn't provide us quite the training that we needed early enough in the program. I think the simulator here in Houston was too busy interfacing with MCC and switching from one building to another and updating to "5" configuration and a whole bunch of other things. We never really got it the "4" configuration. The one down at the Cape took too long to convert from the GT-3 to the GT-4 configuration. As a matter of fact, as early as about 2 weeks before launch I had done four reentries on the simulator down there.

White I did four for the whole time.

McDivitt Is that right?

White My total reentries were four. I remember I got three that day before the launch. I have one thing, though, Jim, that I think that I would do differently.

McDivitt Okay, what's that?

White Now that I know what kind of checklist I need and what kind of procedures books and data books that I need, I'd have those things ready a month ahead of time. I'd use them and get so familiar with them and iron any little bugs out. We still had some bugs in our books.

McDivitt That's right.

White It was a little hard to use. It was a little hard to locate things in there. And if I did anything differently, I'd put my emphasis real early on getting my checklist and data books up, even though I know fully well that they'll change in some little respects right up to the flight, but I'd get them out so I'd have them. We didn't have anything up to a week or 8 days before the flight.

McDivitt That's right. The things like how to do the experiments shouldn't change. They should stay exactly the same. The operational checks should remain the same, and maybe the flight plan will change a little, but you really could have most of those books done long in advance.

White Then you know exactly what information you're going to take up on the flight with you and can get this laid out long in

advance. I think this is one bit of experience that we could pass on to the guys coming behind, particularly the ones that haven't flown before, at least in Gemini – just what information we took along, and the reasons why we took it, and what our recommendations would be, and what we would want to take now. Because remember, you and I sat up there the night before the launch and sifted through a pile of stuff and decided just exactly what we really wanted to take.

McDivitt Of course, on the other hand we knew what we wanted. I think we were just looking for it in that pile of junk that we had on the table.

White Yes.

McDivitt We had that list of things that we'd made up.

White Decided we were going to take. If I had it to do over again, I think I'd have this all in mind earlier.

McDivitt Yes.

White You and I, 2 weeks before the flight, I don't think, fully knew exactly what we wanted, and it wasn't ready for us then, anyhow.

McDivitt Yes. You're right. Matter of fact, some of the stuff we took was our own personal stuff, like those star charts.

White Yes.

McDivitt And that polar star chart was mine, and that Mercator was yours.

White Right.

13.0 MISSION CONTROL

13.1 Go-No-Go

McDivitt Okay. Mission Control. Mission Control is the next major topic. It says describe and discuss updating on the status of the spacecraft on the mission. Go and no-go's, I thought, went pretty well. You have any comment on that?

White No. Sure didn't.

13.2 PLA and CLA Updates

McDivitt PLA's and CLA updates, I thought, went extremely well. You have any other comments on that?

White No. We used the form, and they're easy to copy down. There's sure a lot of information they can get up in a short period of time.

13.3 Consumables

McDivitt The consumables, we had --

White I got some comments on that.

McDivitt Okay. Go ahead.

White Okay, I thought that their monitoring of our electrical system was deficient. I don't believe they gave any indication of what our electrical consumption had been, up till very near the end of the flight, and they informed us that we were 130 or 150 --

McDivitt 160, Ed.

White -- amp-hours over, and I would've liked to know this at discrete times throughout the flight.

McDivitt I think, really, this was our fault. I think we should've called down and asked them. When they did give it to us, they gave it to us because we did call down and ask them.

White Yes, okay. Maybe that was, but I was looking for it more often than that. Maybe we could have this part of the

go—no-go, and they could say you're on your electrical profile and your OAMS profile. This might be a part of it to be sure.

McDivitt Yes. That would be a good idea.

13.4 Flight Plan Changes

White Flight plan changes.

McDivitt Flight plan changes. Well, we had a few. I think that, in general, they all came off where they should. I don't really have any comment.

White We had one area in which they were deficient with the MSC-10.

McDivitt I've already talked to Jerry about that. He says that there was a misunderstanding between us. They sent up to do the MSC-10, and then they said not to do the MSC-10. Do it later. We didn't get the message.

White I didn't hear that.

McDivitt Yes. I thought all the flight planning was good except in this one instance that we're talking about. We were directed to do MSC-10 in one pass, and then before it was done, we were directed to start another check. We got this information pretty late before we started the experiment and hence, didn't get it. We didn't check over the times ourselves, and I guess we should have. So that when we got around to doing it, we found ourselves running into the situation where we were supposed to be doing two experiments at the same time. Fortunately, I think we were able to accomplish all the objectives of both experiments, but there was no need to hurry when we were up there for 4 days.

White Jim, I've got another one too. I've thought a lot about it. I thought about this one before the flight, and I think about it right now. And I thought about it during the flight. I think it's time to start a crusade on the elapsed time. Get us a clock. It's going to cost money, but I think we ought to get ourselves a good elapsed time clock inside the spacecraft. Get FOD to start going on elapsed time. And here's another funny sounding one, but I don't see why we couldn't do it -- why we couldn't have a flight watch in 10-hour increments. Let somebody build a 10-hour watch with a counter on 10-hour increments. And then we'd have the

timing system that we need on the spacecraft. What do you think of that? I know you and I have talked about this before but I think it's time --

McDivitt Yes. We were forced to run our mission using both elapsed time and Greenwich mean time, and it's almost an insurmountable problem.

White I think it's really got our data all fouled up right now, too. I think we'll unsnarl it all right, but, boy, if we could've been putting all our times into those tapes and on our data books in straight elapsed-time increments, and even when it gets into long time, you know, 14-day flights, you can still put in 430 and 20 seconds as well as you can the regular Greenwich mean time.

McDivitt Yes.

White I think that it wouldn't cost us any more to have Omega make us a 10-hour watch and fix these dials up on it so that we could keep track of good elapsed time.

McDivitt You've got to leave the minutes and seconds alone there. Well, let's not argue that here or even discuss it. I think what Ed says is right. We were forced to run the mission in both elapsed and Greenwich time, and I don't think that was the way to do it. I think we ought to really start after this elapsed time thing quickly and get on with it.

White Right. It's time to get on with this. I think it's time to make a crusade on it. I think everybody's ready for it.

McDivitt Yes.

White Except the few people that are fighting it, and I think we can overcome them.

13.5 Systems

McDivitt Okay. Mission Control System. I think the Mission Control on this flight was nothing short of excellent. We got all the information from the ground that we needed. We didn't get bothered by them unnecessarily, I don't believe.

White They were there when you needed them.

McDivitt They were there when we needed them. That's right. I have nothing but praise for the ground control on this flight. How about you, Ed?

White I did too, and I had the feeling up there that I had confidence in what they were doing down there and in the decisions that were being made. I felt that when I needed information that the source was available down there, and I could always get it. That's a very good feeling.

14.0 TRAINING

14.1 Gemini Mission Simulator

McDivitt Okay. Over on training now. The first topic is Gemini Mission Simulator, and I think we touched lightly on this subject already. I think that it's an excellent trainer for procedures, system knowledge, launch, orbit, retrofire, reentry, and crew stations. I think the big problem with it is that it takes too long to turn it around. I think that we're fooling around with it too much, committing it to supporting other functions besides flight crew training. The simulator at the Cape was supposed to have been turned around at roughly 2 weeks after GT-3's launch, and about 6 weeks after the launch it still wasn't doing it's job. When we went down there to start flying this completely checked-out simulator, we found that the launch phase worked, the orbit phase did not work, and the reentry phase did not work. After we got the orbit phase squared away, we found out that we kept losing Reentry Command System. We couldn't use Direct Control Mode in anything. We never did fly reentries until shortly before the actual flight, at which time I think I had four total reentries about a week before the flight. Ed said he only flew four reentries on the simulator at the Cape in total. I probably flew fifteen, I would guess. That's total, so I think that the Gemini Mission Simulator fell down completely in preparing us for this flight.

White Well, not quite that bad, Jim.

McDivitt Well. Okay. We did get a lot of training from it, but I think that the turn-around time is completely inadequate. It made the job for the flight crews a lot tougher than it should have been.

White I don't know really what the problem is, but I think the people down there are working hard, and when things were working right, the training was outstanding. But, gee, there's just too much time when things weren't working right.

McDivitt That's right. I think that's a good point to make. People down at the Cape try very hard, and I don't think it's their problem. The program for the Cape Simulator was done here. When it arrived down at the Cape, it was completely inadequate for the job, and I can't understand why that program wasn't checked out in better shape when it went down there.

White I think, also, they're caught as second-rate citizens as far as keeping their simulators up to date and getting the latest spacecraft changes in them. They seem to be way behind the spacecraft and indicated to me that the system did not permit them to update the simulator with the speed with which it ought to be updated to train the crews properly. The things that were characteristic of Gemini IV were being incorporated in the simulator down there in the last 2 or 3 weeks when they should have been incorporated in the first 2 or 3 weeks after the changeover from GT-3 to GT-4. I think we just have to work on a faster processing of the changes in getting the pieces of equipment and the changes out to the simulator so that they can be incorporated in it. Once they got the changes down there, they got them incorporated into the simulator, seemed like, pretty fast. As long as they weren't there, they couldn't update that simulator. Another thing that I'll, for the life of me, never understand is where in the world the food boxes were for that simulator down there. I think somebody should explain just why it took about 1 month to locate a pair of food boxes and put them on the simulator down there. It was the only way that we could actually work on the storage of the pieces of equipment for our flight, and we didn't get a chance to look at that until what I consider too short a period of time prior to launch.

McDivitt Yes. It seemed like these food boxes were ordered a year in advance, and they never showed up. It looked like there was a complete lack of follow-up on somebody's part here. Then it turned out that they did find the food boxes but didn't release them to the Cape simulator quick enough. I came home here to Houston and found that we had a complete set of good food boxes in the Houston simulator; whereas, the one down at the Cape did not have any at all. This sort of goes along with putting the following missions in front of the mission that's about ready to go. One last comment that I would like to make on the simulator is that we made a mistake in building it so that it would only tilt up 30°. This lying on your back in a simulator is for the birds. You can sit up in it a lot longer than you can lie on your back. Also, everything that you have to do when you're lying on your back is about five times harder than it is when you're sitting up -- nothing at all like zero g. I feel strongly that we should look into some method of making this simulator go all the way up to a 90° point.

White Hear, hear! One other thing on this simulator, too, while we're thinking about it. I think there's no question in my

mind, the most effective trainer we have is our mission simulator. I think it could be made about a third more effective if we had a decent out-the-window horizon provided. We didn't have anything that I'd call satisfactory available to us prior to flight.

McDivitt I agree.

14.2 LTV Simulation

McDivitt LTV Simulation. I think that on the two trips that we made to LTV to do the abort simulations we got as much for an hour of time spent as we did in any other part of our training. We were able to do a great number of runs in a very short period of time, and we got all our abort procedures down pat in just a very short period of time. I think that I can't say enough for this. I certainly will be glad when we get this type of a simulation at MSC so that we don't have to travel out of town to get this kind of training.

White I hope they can get it so it works as well as it does up there, down here, because one thing that impressed me was that you could go up there and be able to run 70 runs.

McDivitt That's right. In a day.

White And not sit around waiting for things to get fixed all the time.

McDivitt I think on the one day we went up there, Ed and I together, in one day, had about 160 runs.

White Yes. Pretty close to that.

14.3 Centrifuge

McDivitt Centrifuge. I think that the centrifuge contributed very little to our mission. I sort of feel that once you've been on the centrifuge and you've learned what the effect of g's are and how to counteract their effects, that there's not a great deal more to be gained. I didn't really feel that I got that much out of the centrifuge time. How about you, Ed?

White I think that your orientation in the centrifuge is very important. In other words, I think that it does give you a feeling for what the g's are going to be like and what the

g's on the lift-off and reentry are. I don't believe there's any necessity for beating your head on a centrifuge over and over, running it up there. I certainly wouldn't want to go run a series of runs just before the mission so I'd know how it's going to feel on launch, because I already know how it's going to feel on launch. The first time you run a few runs on a centrifuge, you know pretty well what it feels like. I think that it's good in moderation, but I certainly don't think you should over-train on it. It's not something that you need to train on every time for every flight.

14.4 Translation and Docking Trainer

McDivitt — Translation and Docking Trainer. I thought that the Translation and Docking Trainer was an excellent trainer for the D-6 pass that we did, the Apollo Tracking Pass. I think that the simulation that we set up at Martin, Denver, was also an excellent tracking task for this, and I sort of felt that we got the techniques from these two trainers that we needed to successfully perform this experiment.

White — I have a couple of comments on that. I felt the same way. Of course, we didn't have this trainer used too much for the docking phase, but I thought it was quite good for the tracking aspects and also for thruster failure.

McDivitt — That's right. It gave you a dynamic simulation of a thruster failure and what you could do and what you could notice when you actually have a thruster that failed. I used it quite a bit shortly before the flight to practice the docking and the station-keeping that we never really got a chance to perform in flight. I felt that it was quite valuable for this.

White — Yes. I think that it's a very good simulation, too, of the actual way the spacecraft really moved.

McDivitt — Yes. I think it is too. I think it is too. Anything else on Translation and Docking Trainer?

White — No.

14.5 Planetarium

McDivitt — Planetarium.

White I think it's very valuable training. We used this one down here in Houston, and we used the Morehead Planetarium. There's not a bit of question in my mind which one you ought to use, and it's Morehead, because the display of the stars is about as close as you can get to the real stars out in the sky; whereas, in the one down in Houston, the projection of the stars just doesn't have the quality to provide the information that you want to get. I have one other comment, though, as far as the stars are concerned. I think that probably we got as good training with our stars during our night flights as we got during the planetarium work.

McDivitt I feel that's true too. You've got to go to those planetariums to see all the stars in the sky, but the night flying we did with our star chart was probably the thing that really imbedded the location of these stars in my mind. I kept looking at them night after night after night after night, and when we flew I was convinced that I could go up there and find all those stars that I needed to find. I think I had no trouble at all finding them.

White Yes. We saw every one that was out at night. I think we saw them all. I think we can come back with good identification on them, and whatever information they want us to tell about them, we can tell them.

McDivitt That's right. And where we didn't know the exact name of a particular star in a constellation, we could always tell which star it was in the constellation and be able to find the name of the star after we got back here to the ground. But I do think that the star training we had was worth every minute of it.

White Yes, I'd go back some more, too. I'd go back to the planetarium some more.

McDivitt That's right. It's one of the things that you really have to keep at all the time, because you can never go out at night and look at all the stars in the sky. You can only see a certain restricted area, and it takes a lot of looking to see the whole sky. By the time you look long enough to see the whole sky, it's 6 months since you've seen certain stars, unless you want to stay up all night.

White Spacecraft orientation. I think the little devices they gimned up at the Morehead Planetarium are real good in this respect. You can sit there and they can simulate your orbit. They can put you up in the barber chair and you look out and

see approximately the number of stars you can see out the spacecraft, and I thought that's about what I could see out of the spacecraft. When I actually got up close to the window, when we were up flying, I could see more stars, as I thought I could. I thought that the training we received was good.

McDivitt Yes. No doubt about it, that was all time well spent.

14.6 Systems Briefings

McDivitt Systems Briefings. We actually had briefings on every system in the spacecraft, and there are quite a number of them. The schedule was such that we had a general briefing here at Manned Spacecraft Center on each and every one of these systems. I think we had a second briefing here at the Manned Spacecraft Center on certain systems like the ECS before we went to the altitude chamber. We had a number of briefings on the systems again up at McDonnell by McDonnell engineers in St. Louis. We went down to the Cape, we had another general briefing by the McDonnell engineers at the Cape probably 6 weeks before the flight, and then about 10 days before the flight we had a final systems briefing where they just discussed any changes that had been made since the previous briefing and brought us up to date on some of the things that had occurred during this spacecraft systems testing. I thought every one of these systems briefings was worthwhile, and I think without each and every one of them we would have been much worse off than we were. I think that if I had it to do all over again, I'd schedule them in just exactly the same manner we did this time. One or two here at the Manned Spacecraft Center, then again up at the contractor, then a couple of them down at the Cape. Any comment on that?

White No. I liked the manner in which they were presented, as a buildup of details as we went along. The final ones down at the Cape were just certainly not systems briefings. They were details of the system briefings.

14.7 Flight Experiments

McDivitt Right. Flight Experiments. Simulations. We didn't have to do any simulations on MSC-1, -2, and -3. They were just throwing switches. The medical experiments, the Calcium Deposit Experiment and the Bone Demineralization Experiment

required that we have a number of X-rays taken and we did indeed go make a couple of dry runs and a couple of wet runs on the X-ray table to make sure that we could get it done quickly. I think this paid off. We never had any delay due to these X-rays. We certainly all know how to use the exerciser. And the phonocardiogram needed no practice. S-5 and S-6 did not require any training here on the ground, because these were supposed to be photographs from orbit. That thing was impossible to simulate on the ground. The D-8 required no simulation, so it boiled down to D-6, D-1, and D-9 as the experiments that required simulation prior to flight. As we said earlier, we felt that the Translation and Docking Trainer and the Martin, Denver simulation for the D-6 experiment were very valuable. They gave us the techniques that we needed to perform this thing in space. Gemini Mission Simulator was invaluable, too, for everything -- for experiments, operational checks and for the whole mission.

White — As far as any real D-9 work, though, with the simulator all we could go through were kind of cursory procedures. There was no star field or anything to utilize, which I think would be useful. If we had a decent star field, we could use it out of the GMS. Also, on D-6 the GMS did not provide us anything we could use. There were procedures, right. And like you said, the Translation and Docking was all right for D-6, but, practically, we had no simulator anywhere that gave us anything that I could get out for D-9.

McDivitt — Okay. Are we through with the briefings? We had a real major briefing that lasted 3 or 4 days here at the Manned Spacecraft Center about 4 months prior to the flight. Wasn't it, Ed?

White — Yes. Well, was it that long? It was in March or April -- March wasn't it? Somewhere around there.

McDivitt — I thought it was later than that. We had our first real major briefing 3 months before the flight, on March 8, and we had the experimenters come to Houston and go over their experiments in great detail to explain what they wanted and how they wanted us to go about getting it. I thought this was very good. We had another briefing on experiments in the flight plan review about 6 weeks before the flight, and we had another experiments review about 10 days to 2 weeks before the flight. Again, I felt that each and every one of these was certainly time well spent. I think that, probably, the first experiments briefing might have taken place a little sooner.

White — I've got a comment on D-6 here. Ten days before the flight, they came in with the information for D-6 and said, "How do you want to run the tracking on D-6 and send the information up?" This was not the time to bring up this type of information or try to make this type of decision. These decisions should have all be firmed up at the 6-weeks briefing, and this is what the 6-weeks briefing was for. It was to tell us how we were going to run our experiments. After that time there weren't supposed to be any changes to the procedures, and 10 days before the flight was just to incorporate any last-minute changes and solidify any things that might not be understood too well in the procedures. So this is where, I think, that the people giving this information in D-6 never were with it -- as far as getting the information ready for us for it.

McDivitt — Very good. I concur completely.

White — In the future I think the experiments should be firmed up by six weeks prior to flight and the procedures should be well in hand at that time. They shouldn't drag on and be dragging on right on down to a few days before the launch, which is exactly what happened on D-6.

McDivitt — Okay. Equipment. We had some of the equipment available to us as early as 6 or 8 months before the flight. Other equipment kept dragging in until the very last day, just about. I don't believe that you can get the training equipment available to the crews too early. We found ourselves, in many cases, with the training equipment locked up out at the Cape for safe keeping -- so safe that we couldn't even get to it, and we didn't get a chance to use it the way we should have. I think only by a lot of noise making, I guess, were we able to ever break this stuff loose. Training equipment is just what it says -- it should be used for training, and it should not be kept under lock and key away from the crews.

White — I had that same feeling down there, Jim. I think we both kind of got on this one. It seemed like they'd want to get all the training equipment all together and say, "Ha, ha. We've got it all together. We're all up to snuff. There's all of our training equipment. It's all in that locker over there." That's not the way it ought to be. The training equipment shouldn't be in that locker at all. It should all be out to the crew.

McDivitt — In the hands of the crew.

White — And I think up in the crew quarters is where the training equipment belongs and down in the simulator. It should be out and being used. I think that one of the keynotes to our success in having a decent amount of photography taken on the flight was that we took the cameras that were available, whether they were flight type or the commercial types of cameras that we carried, and became very very familiar with them in the months before the flight. I recommend very highly that crews that follow in the future get the equipment and utilize it so that it becomes second nature to them prior to the flight.

McDivitt — Okay. I don't think we need any more on that, do you?

14.8 Spacecraft Systems Test

McDivitt — I think that we learned quite a bit from our spacecraft systems tests. We had a great number of them in St. Louis and then down at the Cape. I think that the amount that we learned and the time we spent was a little low. I think the ratio of what you got for your hours spent was low, but I do feel that it's a necessary thing and that you really should participate in this spacecraft testing. There were long periods of time when we learned nothing, absolutely nothing, but on the other hand we got a feel for our spacecraft and saw how a lot of the systems were working and the only way you can do this is to actually participate in the testing.

White — You know, it doesn't seem to fit in there anywhere else, but I think maybe at this point we ought to indicate we attended every one of the management meetings up there at McDonnell while our spacecraft was up there progressing along through the assembly line. I recommend that all crews in the future have representation at all those meetings.

McDivitt — That's right. The most important meetings I've ever gone to in my life, at least since I've come here to the Manned Spacecraft Center, were those Gemini management meetings up at McDonnell. I can't express enough the need for a representative of the flight crews to be there at the meetings.

14.9 Egress Training

McDivitt — Egress Training. I thought the briefings were excellent, the flotation tank work was excellent, the Gulf exercise was excellent, and the survival gear briefing was excellent. I

can't say how glad I am that we've had this training when we plopped down out in the Atlantic Ocean and we were sitting there. Even though we were about to be rescued, I knew that even if they didn't rescue us right then, I felt fully confident about being able to take care of myself out there in that water.

White We were well prepared in this area.

14.10 Parachute Training

McDivitt Parachute Training. I thought that the parachute training that we had was good. I thought that the parachute training into the water with pressure suits on was by far the best that we had. It was the most realistic and it was the kind of training that we would need during actual flight.

White And I recommend highly that all crews do this, and they go in suits as close to the same kind of condition that you're going to plop down in that water with, and go through the full inflation and not skimp on a thing.

McDivitt You get all tangled up in a parachute just the way you're going to get all tangled up in the parachute when --

White That's right. Inflate the life rafts, and inflate the Mae Wests, and inflate the whole works every time. And if we don't have enough life rafts to do it every time, see to it that we get it.

14.11 Launch Simulation

McDivitt Okay. Launch Simulation. I think that the launch simulations were excellent. I think that was the first place that we really had a chance to work with the people who were going to be controlling us during the flight. I think we got a lot out of it, and I think they got a lot out of it. What we really had to do was learn, I guess, respect for each other, and I guess the only way we could do this was to see how each of us was going to handle a situation that arose. I don't have any other comments on it except that I think that it was certainly worthwhile.

White I've got a comment. Not on that, but a thing that fits right in.

McDivitt Shoot.

White I think that the reentry simulations that we did should be made a regular part of the preparations for flight. It's just as important to me as the launch simulation. I think there should be regular reentry simulation for the preparations prior to the flight in the same manner as the launch simulations.

McDivitt I think so too. I think those reentry simulations we did that day were certainly worthwhile. We only had to do a few of them to learn the procedures for getting the information back and forth. We tried one one day, and it was so horrible that I'm certainly glad that something like that didn't happen during flight. But after we had done a couple more, it smoothed out, I had no doubt in my mind whatsoever that we were going to be able to pass the information back and forth.

White That's right. I felt that they were equally as important as the launch simulation.

14.12 Network Simulation

McDivitt The Network Simulation. We didn't actually participate in the network simulations, and I don't think we missed a thing. I think, though, that something that was required was a discussion with the Network Controllers. We came back to Houston to tell them our points of view and explain to them the kind of information we wanted passed back and forth and the format of how we wanted this information given to us. I think that during the flight it certainly proved that it was worthwhile, because that was the way we got it, and we were able to get this information in a usable manner in a short time. We didn't have to go over and over and over. I don't have any other comment on that. Ed?

White No.

14.13 Zero-G Flight

McDivitt The zero-g flights are the next topic. I sort of feel that the zero-g flights were one of our most valuable training tools, especially since we were going to do the extravehicular activity portion of the flight. Without this we wouldn't have had the confidence in ourselves in getting in and out of the spacecraft and opening and closing the hatch that was required,

so that we probably wouldn't have even done it. Ed, do you have any other comments on that?

White Concerning the little bit of a hatch problem that we did have, I think that the work that I had done on the zero-g airplane sure prepared me well to meet the problem that we had. I recommend very highly that for any egress work, in which we're going in and out of the spacecraft zero-g, that you get up there and work the procedures out thoroughly between not only the guy getting in and out but between the two guys that are sitting in the seats. This is the way we flew it. We didn't go up there and fly just one guy jumping in and out the hatch. We went up there and flew with the guy in both seats, whether the man in the left seat actually worked all the time or not. There were times when he had to help, and in our flight, it paid off because there was a time when Jim had to help, and he knew exactly what the problems were and was able to give the help necessary.

McDivitt Another thing that might have helped here was that I've been in and out of that right-hand hatch almost as many times as Ed had.

White So we knew just what the problems were.

McDivitt So we knew exactly what the problems were.

14.14 Flight Plan Training

McDivitt Next topic is Flight Plan Training. I think we had such a great number of changes in our flight plan that it's really not fair to discuss this in any great detail. The approach that we did take, as I mentioned earlier, was that we would have a good launch and first few orbits, a good retro-preparation, and a good retro and reentry, with the center of the mission being taken care of by doing the experiment or doing the operational check by itself without regard to what went before or what went after. I think this is the kind of training you really need on these long duration flights. Anything else there, Ed?

White No. I concur heartily. I think that practicing it piecemeal is the only way you can do it.

McDivitt You have any concluding comments?

White I think we've been making conclusions all day long. I think to try to conclude them all, we'd never get them.